Ministry of
Northern Development
and Mines
Ontario

Precambrian Geology
Slate Islands

Ontario Geological Survey
Report 264

1991

"MY SLATE ISLAND HOME"

I remember the lights of the lake boats at night
As they passed by our lighthouse, that tower of white
That beamed out their safety atop its red dome
And all was serene on my Slate Island Home.

I remember the days and the thousands of ways
That a boy could grow wise during fine summer stays
On those isles of adventure, where beaver and trout
Awaited the adventure of three boys in a boat.

When my two brothers would call "Hurry, Joe".
So we manned the oars and off we would go
In search of the fun that we knew would be there
Once we cast off our worries and set sail from our cares.

As Peter King's sons, we lived up to his name:
Our strong, sturdy sire who sought not for fame,
But contented himself with keeping the light
Which guarded those freighters that pass in the night.

We roamed through the islands, we traversed the lakes
Fishing, exploring, doing all that it takes
To make boys happy when given the chance
To hear Nature's song and take part in her Dance.

And often to Jackfish we took our small craft
And greeted the man from C.P. telegraph;
We gathered the mail with care and with pride
For we'd learned to respect the import of our ride.

The trip took a full day but we did not mind
Completing the task which our father's assigned
For upon our return we knew we'd be met
With satisfaction from father, and, better yet —

In our frame cottage, there mother would be
With good food and cakes for my brothers and me;
And later we'd sing by the warmth of the fires
While mother and father enjoyed our small choir.

Oh, the hymns, I could sing now to those by gone days
Of learning the waters, and learning the ways
Of Nature, and beauty, when we use to roam
Amid the sweet joys of my Slate Island Home.

But the freighters still pass by the lighthouse still stands
And other folks put time at exploring the lands
And I'm quite happy with thoughts of my own,
Of gay, carefree summers on my Slate Island Home.

— Joseph King, son of the first lighthouse keeper on Slate Islands

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R.P. Sage

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GEOLOGICAL MAP

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Foreword

The Slate Islands straddle the Superior Province–Southern Province boundary and contain a wide variety of Proterozoic and Archean rock types. Coarse volcanic breccias of Archean age indicate the site was proximal to an Archean volcanic vent. Plentiful dike intrusions of later Precambrian age imply that Proterozoic volcanism may also have occurred at this site. The presence of shock metamorphic features has stimulated controversy over the origin of the islands. Whether one favours meteorite impact origin or an endogenous origin, the islands will remain of scientific interest for many years to come.

V.G. Milne

Director
Ontario Geological Survey

Abstract

The Slate Islands have a total surface area of approximately 40 km² and lie in the northeast corner of Lake Superior approximately 10 km offshore from the town of Terrace Bay. Most of the rocks on the islands belong to the Wawa Subprovince of the Superior Province, but a small exposure of Keweenawan volcanic flows belongs to the Southern Province of the Lake Superior basin. The Slate Islands are located at the intersection of two major crustal fractures cutting the Lake Superior basin. Along one of these fractures, which strikes northeast, the Mohorovichic discontinuity is interpreted to be at depth of approximately 60 km, the greatest depth reported in North America. Alkalic magmatism characterises the on-shore northern extension of this northeast-trending fracture. Lake bottom contour maps indicate that the islands lie on a topographically high ridge that crosses the bottom of Lake Superior parallel to one of the crustal fractures. This ridge is older than Keweenawan, based on the fact that flood basalt basins do not cross this ridge and on the basis of paleomagnetic data.

The Archean rocks on the islands are dominantly volcanic in origin with associated intrusive rocks and minor intercalations of sedimentary rocks and iron formation. These supracrustal rocks have been metamorphosed to the greenschist facies rank of regional metamorphism. The volcanic rocks range in chemical composition from tholeiitic basalt to calc-alkaline rhyolite, and one complete and one partial mafic to felsic volcanic cycle can be recognized. Coarse felsic fragmental rocks, particularly in the southeast corner of Patterson Island, suggest that the islands were proximal to an Archean volcanic centre. The Archean rocks appear to have been isoclinally folded into a northeast-trending pattern similar to a nearby sequence on the mainland. At a later time in the Archean this folded sequence was subsequently refolded around a steeply southwest-plunging fold axis.

During the Animikie period of the Proterozoic, a thin unit of Gunflint iron formation and minor units of Rove Formation were laid down unconformably on the Archean rocks. In late Proterozoic time (Keweenawan) a sequence of tholeiitic mafic volcanic rocks with some thin arkosic sandstone interbeds was laid down on the Animikie rocks. Synchronous with the extrusion of the mafic flows the islands were intruded by a pervasive swarm of diabase dikes which likely served as feeders for the flows.

Subsequent to the extrusion and intrusion of the Keweenawan rocks all rock types were intruded by Paleozoic diatremes in a pattern of ramifying breccia dikes. Associated with diatreme emplacement was the development of the shock metamorphic features: shatter cones and lamellae in quartz grains. The diatreme emplacement and associated shock features are probably related to alkalic magmatism associated with the crustal fracture that strikes northeast across the Lake Superior basin. This northeast trending fracture (Big Bay–Ashburton Bay Fault) intersects a second major crustal fracture (Michipicoten Island Fault) trending just north of west immediately south of the Slate Islands.

The islands have been prospected for gold and two showings have been located. The rock types found on the islands are favorable for the presence of massive sulphide (copper-zinc) deposits.

Sage, R.P. 1991. Precambrian geology, Slate Islands; Ontario Geological Survey, Report 264, 111p.

Résumé

Les îles Slate ont une superficie totale de 40 km² et sont situées à l'extrémité nord-est du lac Supérieur, à environ 10 km des rives de Terrace Bay. La plupart des roches des îles font partie de la sous-province Wawa de la province Supérieure mais un petit affleurement de coulées volcaniques keweenawaniennes fait partie de la province Sud du bassin hydrographique du lac Supérieur. Les îles Slate sont situées à l'intersection de deux importantes fractures crustales qui traversent le bassin hydrographique du lac Supérieur. La discontinuité de Mohorovichic est située le long d'une de ces fractures, orientée vers l'est, et on estime que sa profondeur est d'environ 60 km, la plus profonde discontinuité découverte en Amérique du Nord. L'extension terrestre nord de la fracture orientée vers le nord-est est formée essentiellement de magma alcalin. Les cartes en courbes de niveau du fond du lac indiquent que les îles reposent sur une haute crête qui traverse le fond du lac Supérieur dans la même direction qu'une des fractures crustales. Compte tenu du fait que les plaines d'inondation de basalte ne traversent pas cette crête et selon les données paléomagnétiques recueillies, la crête est antérieure au keweenawanien.

Les roches archéennes des îles sont principalement d'origine volcanique. On retrouve également des roches intrusives et quelques intercalations de roches sédimentaires et de fer. Ces roches supracrustales ont été métamorphisées en faciès de schiste vert du métamorphisme général. La composition chimique des roches volcaniques est très variée; on note la présence de basalte tholéitique et de rhyolite calco-alcaline et de deux cycles volcaniques mafite-felsite, l'un complet et l'autre partiel. La présence de gros fragments de felsite, principalement dans le secteur sud-est de l'île Patterson, semble indiquer que les îles étaient situées près d'un centre volcanique archéen. Les roches archéennes semblent être plissées de façon isoclinale selon une direction nord-est. Ces plis rappellent ceux d'une séquence relevée sur la terre ferme. Plus tard dans la période archéenne, cette séquence a été replissée selon un axe de pli plongeant orienté vers le sud-ouest.

Lors de la période Animikie du protérozoïque, une mince formation de fer de Gunflint et quelques unités de la formation de Rove se sont déposées de façon discordante sur les roches archéennes. À la fin de la période protérozoïque (keweenawanien), une séquence de roches volcaniques mafiques tholéitiques interstratifiée de grès feldspathique mince s'est déposée sur les roches Animikie. Lors de l'extrusion des coulées mafiques, des filons de diabase, qui ont sans doute été les filons nourriciers des coulées, ont fait intrusion dans les îles.

Suite à l'extrusion et à l'intrusion des roches keweenawanienne, des diatrèmes paléozoïques ont fait intrusion dans tous les types de roches sous forme de brèches intrusives ramifiées. Les diatrèmes, en raison de leur emplacement, ont entraîné le développement des formations métamorphiques sismiques ce qui a causé la présence de cônes de dislocation et de lamelles dans les grains de quartz. L'emplacement des diatrèmes et les caractéristiques sismiques qui en résultent sont sans doute liés au magmatisme alcalin associé à la fracture crustale orientée vers le nord-est qui traverse le bassin hydrographique du lac Supérieur. Cette fracture nord-est (faille Big Bay–Ashburton Bay) croise une autre importante fracture crustale (faille de l'île Michipicoten) orientée nord-ouest et située au sud des îles Slate.

On a prospecté les îles et deux sites d'or possibles ont été relevés. En raison du type de roche qu'on y retrouve, les îles pourraient également renfermer d'importants dépôts de sulfure (cuivre-zinc).

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Precambrian Geology
Slate Islands

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Introduction

The Slate Islands are located at approximately 48°39'30"N Latitude and 87°00'00"W Longitude in the northeast corner of Lake Superior. The islands lie largely within the Wawa Subprovince of the Superior Province.

The islands had been last mapped by Parsons (1918) and during 1974 a one-year program was undertaken to reinvestigate the islands in the light of changing geologic concepts.

The islands underwent extensive prospecting for gold just before 1900, and several gold showings were uncovered at that time. Between 1960 and 1963 the islands were again examined by Kimberly–Clark (Canada) Limited for their gold potential. This work disclosed the presence of high grade gold values over narrow widths and short strike lengths at the north end of Horace Cove. In addition to the known gold showings, mapping during the 1974 field season disclosed rocks known to be highly favorable to the occurrence of massive sulphide deposits.

Acknowledgments

The author was ably assisted by B. Campbell, D. Meloche, and D. Bathe, junior assistants. K. Treacher, senior assistant, was responsible for about 40% of the mapping and D. Meloche and D. Bathe both assumed the duties of senior mapping assistant for special projects of short duration. Local fisherman and in particular M. Osmer and K. Johnson, of Terrace Bay, greatly assisted the crew by providing much local information. During the latter part of the mapping project Dean Johnson and John Daley of Terrace Bay served as temporary junior geological assistants.

R. Kenney and A. King, both of Rossport, J. Bryson of Schreiber, A. Amos of Terrace Bay, and J. King, P. Dahl and J. Styffe, all of Thunder Bay, provided the author with verbal and written acounts of unpublished and unrecorded events of the early history of the islands.

Location and Access

The Slate Islands comprise a group of 17 islands and islets in the northeast corner of Lake Superior (Figure 1). The islands cover an area of approximately 40 km² and are characterized by an irregular and often precipitous coastline.

The islands are approximately 10 km south of the town of Terrace Bay which is located on the north coast of Lake Superior and is served by Highway 17 and the Canadian Pacific railway. The best way to get to the islands is by boat from Terrace Bay. Other points of departure include Schreiber or Rossport. Most watercraft going to the islands depart from the mouth of the Aguasabon River at Terrace Bay which provides a sheltered harbour for shallow draft boats.

During the mapping project, the islands were visited by yachts from the Detroit area, a sailing ship from Thunder Bay, a cutter of the Royal Canadian Mounted Police and a trawler of Marine Services, Transport Canada, working on navigation aids on Lake Superior. The generally deep water surrounding and within the island complex allows ready access to deeper draft lake boats which sometimes enter the interior waterways, seeking shelter from storms on the lake.

Field Methods

Field mapping was conducted between May 23 and August 15, 1974. Mapping was plotted on acetate overlays of airphotos at a scale of 1 inch to 1/4 mile supplied by the Airphoto Library, Ontario Ministry of Natural Resources, Toronto. Data was transferred from the acetates to a cronaflex base map supplied by the Cartogra-

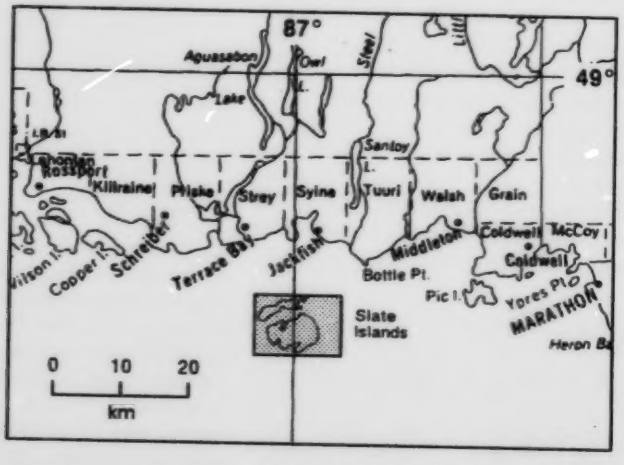

Figure 1. Key map showing location of Slate Islands; scale 1:1 584 000.

phy Section, Ministry of Natural Resources. Because of the geologic complexity the cronoflex was enlarged by a factor of 2 and the data was transfered to the cronaflex from enlargements (2X) of the acetate overlays.

Mapping of the coastline was largely confined to the wave washed area where primary textures of the rocks are most likely to be observed. The local areas of the coast where precipitous cliffs exist were traversed by boat and observations were often brief, being dependent on lake conditions at the time of observation. The other areas of the coast were walked. Gaps in traversing along the coast, either by boat or by foot, do not exceed 30 m in length.

On Patterson Island shearing has often obliterated the primary textures and locally a somewhat interpretive approach was taken in mapping. Along the protected interior waterways of McColl Island, Bowes Island, "Whitefish Bay[1]", and Lawrence Bay, low outcrop with overhanging brush made mapping very difficult. Along the north coast of Mortimer Island and along the coastlines of several other islands, shearing parallel to the coastline was not plotted on the map to avoid interference with other geologic data and structural symbols. Due to its complexity, the geology of the west coast of Patterson Island has been shown on the map in a more generalized way than other areas. The Keweenawan section here, particularly its basal section, is structurally complex and has consequently been greatly simplified on the map. In some cases it was difficult to distinguish between fault and diatreme breccias, however, in the vast majority of cases the polymictic and crosscutting relations of the diatreme breccias were clearly visible.

Mapping of the coastline of most of the main island and all the outlying islands was done by the author. The area of the southern coast from just east of Horace cove to just west of Cove Island was only briefly examined at isolated spots by the author. This section of the coast of Patterson Island was mapped by K. Treacher who also did the interior traversing of Mortimer and Patterson Islands. D. Meloche assisted by D. Bathe mapped the coastline of Whitefish and Lawrence Bays on Patterson Island and prepared a detailed geologic map of a portion of the Keweenawan along the west coast.

In the fall of 1974 the field notes of G.E. Parsons, consulting geologist, Toronto, who worked on the islands for Kimberley-Clark Canada Limited during 1960–1963 were obtained and his data were incorporated into the map. The interpretation of these field notes and the resolution of any differences between the work of this party and that during 1960–1963 is that of the author.

During the process of mapping the island, all quartz veins were routinely sampled and checked for their gold content. All sulphide showings were sampled and submitted for emission spectrographic analysis. If the sulphides showed the presence of anomalous base metals, additional assays were performed. Sediment samples were routinely obtained from all streams flowing into the lake or encountered on traversing and checked for their heavy metal content. All analytical work was by the Geoscience Laboratories, Ontario Geological Survey, Toronto.

The field map was originally published at a scale of 1 inch to 1/4 mile and 1 inch to 660 feet (Sage et al. 1975). The accompanying map, at a scale of 1:10 000, was derived from the field map with modifications based on laboratory, petrographic, and analytical work.

Previous Geological Work

Bow (1899) mentioned that prospecting was in progress on the islands at that time and at a later date mentioned that mining operations had been in progress since December 1899 (Bow 1900). The islands were at this time owned by J.C. Patterson, lieutenant-governor of Manitoba.

Coleman (1901) prepared the first published geologic description of the island group after visiting briefly to investigate reports of iron deposits. Parsons (1918) investigated the presence of gold deposits on the island and published a more comprehensive geologic description.

From 1960 to 1963 Kimberly-Clark of Canada Limited under the direction of G.E. Parson, consulting geologist, Toronto, conducted an investigation of the economic potential of the gold deposits of island (G.L. Puttock, President, Kimberly-Clark of Canada Limited, personal communication, 1974).

In the surrounding area, Harcourt (1938) mapped the Schreiber area at a scale of 1 inch to 1/2 mile, and Walker (1967) completed a geologic survey in the adjacent Jackfish-Middleton area at the same scale. Giguere (1975) mapped St. Ignace Island and the smaller islands east of St. Ignace Island at a scale of 1 inch to 1 mile. Puskas (1967) mapped the alkalic intrusion in the Port Coldwell-Marathon area east of the Slate Islands at a scale of 1 inch to 1/2 mile.

Selected reference material published after 1975 has been incorporated in the report in 1979 and 1988. All references added in 1979 and 1988 deal solely with the Slate Islands and no attempt has been made to update other portions of the report.

The islands are covered by Aeromagnetic Map 2146 (ODM-GSC 1963) at a scale of 1 inch to 1 mile.

Topography

The Slate Islands reach a maximum elevation of 311 m above sea level at the west end of Mortimer Island, 128 m above the present lake level which is recorded at 182 m above sea level. The islands thus stand out in sharp relief from the surrounding lake. The exposed coasts of Mortimer and Patterson Island are rugged and often precipitous. The wave action of Lake Superior has carved numerous grottos, walls, spires, and coves along the wave washed margins of the larger islands making access to the more exposed sections of the coast hazardous except in the calmest of weather. The ruggedness of

[1]Unofficial, local geographic names are indicated by quotation marks.

the coastline of Mortimer Island is largely due to selective erosion along numerous shear zones that cut the mafic metavolcanic assemblage on this island. On Patterson Island abundant basalt and diabase dikes cut the schistose metavolcanics. The resistance of these dikes combined with rapid erosion of the schistose rocks has been the dominant factor in creating the rugged coastline of this island which is the largest of the Slate Islands group.

In the interior of the islands the topography is much less rugged although dikes on Patterson Island sometimes form walls which make traversing difficult. On Patterson Island the peaks and hills are formed of massive Archean metadiorite or the larger of the Keweenawan diabase dikes.

Of the smaller islands within the Slate Island group, Delaute has precipitous sections of coastline along its eastern, northern and western margins, however Dupuis and islands of the Leadman Islands generally have a relatively low profile. The Slate Islands are covered by 1:50 000 scale topographic maps: Pic Island 42D/10 and Slate Island 42D/11 produced by the Surveys and Mapping Branch, Energy, Mines and Resources Canada.

Hydrographic map 2303 published by the Canadian Hydrographic Service, Marine Services Branch, Energy, Mines and Resources Canada, at a scale of 1:72 968 indicates that water depths increase rapidly to 240 m immediately southwest and southeast of the island group. Trending in a northeast direction from the island group is a zone of much shallower water depths which would join the mainland in the vicinity of Lawson Island in Santoy Bay. The structural and lithologic trends observed on the eastern portion of Patterson Island and all the other islands is conformable to the trends established by Walker (1967) in the Archean supracrustal rocks on the mainland. Presumably this zone of shallower water represents a ridge of Archean supracrustal rocks that provides a direct link with the mainland. The hydrographic maps indicate a rugged topography for the lake bottom close to the islands. The maximum bedrock relief of the islands measured from the lake bottom close to the islands to the highest point found on the islands would be at least 408 m.

Weather

Based on the experience of personnel working on this project, weather on the islands is often different from that occurring at the same time on the mainland. Ice did not melt from all the crevasses on the island until after the third week of June and on occasion ice formed during the night on the interior coves and bays of the islands up to the middle of June. The trees did not develop foliage until the latter part of June and during the entire field season the temperature was generally cool, rarely exceeding 20°C. Rain was not excessive and only about 20% lost time was due to rain. High and variable winds made field work on the coastline hazardous and at times prevented work.

The fog surrounding the islands is unpredictable and is another hazard to field work. Fog banks reducing visibility to less than 60 m may develop in less than an hour. On some days field work could be done in the interior of the island while the fog was so dense around the perimeter of the island that navigation was impossible in the external waterways or along the outer coast. The fog in these instances appeared to be a ring-shaped cloud bank which completely enclosed the main islands of Mortimer and Patterson allowing the sun to shine on the interior portion of Patterson Island. During the latter part of the field season the intensity and frequency of storms increased and fog became more common.

Anyone anticipating visiting or working on the islands should be prepared to deal with rapidly changing climatic conditions.

Fauna and Flora

The islands are noted for the presence of a herd of woodland caribou which has been estimated at approximately 45 animals (T. Timmerman, Regional Biologist, Ontario Ministry of Natural Resources, personal communication, 1974) to 175–200 animals (Butler and Bergerund 1978). The caribou arrived on the islands from the mainland by crossing the ice in 1907 (Butler and Bergerund 1978). Beaver and rabbits are prolific on the island and during the early spring the author noted that the bird population contains many colourful species. Field mice, brown bats, garter snakes, and one unidentified member of the weasel family were observed, and evidence for the presence of fox was found. Ducks, and seagulls are common on the interior waterways of Lake Superior and a heron was observed at one of the interior lakes. In addition Euler et al. (1974) reported the presence of muskrat and otter. The waters of Lake Superior surrounding the islands are noted for their lake trout.

The Slate Islands are presently covered with a heavy timber growth consisting of white spruce, black spruce, balsam fir, white birch, mountain ash, balsam poplar, trembling aspen, pin cherry, mountain maple, and white cedar (Euler et al. 1974). The islands are also reported to contain several species of near arctic and true arctic plants (Euler et al. 1974). The most interesting of these arctic plants is the mouse-ear chickweed which has been reported on Leadman Island (Morton 1971). This plant, which is usually confined to arctic regions or high mountains, is thought to be present on Leadman Island as a relict of the last ice age (Morton 1971). Its presence on Leadman Island represents the most southern latitude at which this species has been found (Morton 1971).

History

During the summer of 1974, personnel of the Historical Sites Branch (Ontario Ministry of Natural Resources, Thunder Bay) briefly examined the Slate Islands (Newton et al. 1974). This work disclosed an aboriginal campsite of Oneota culture on Mortimer Island and a campsite of Iroquoian culture on Patterson Island (Newton et al. 1974). A guess for the date for these visitations is 1500–1600 AD prior to European influence (W. Fox,

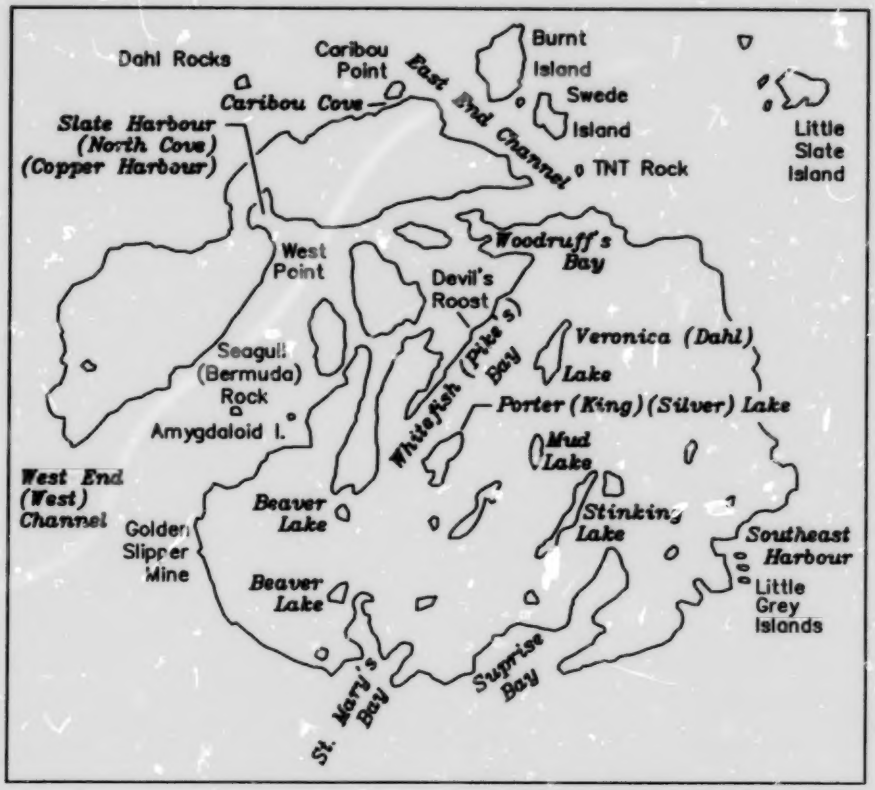

Figure 4. Local geographic names, alternative names of equal usage given in brackets.

At the old campsite a large barge presently rests on a log crib-work where it was sunk. This barge was operated by the Pigeon Timber Company Limited and was originally used to haul horses to the island to work in the pulp wood operations.

Geographic Nomenclature

One of the first problems in determining the history of a region is the establishment of communication with people familiar with the area. Conversations with many local people and examination of old maps indicate that a relatively large number of names have been applied to identical geographic features on the Islands. One of the best examples of multiple naming is Lambton Cove on Mortimer Island. Early survey plots available for examination in the Surveys Record Office, Ministry of Natural Resources and dated 1872 and 1877 indicate that this geographic feature was first named "Slate Harbour". Parsons (1918, p.163) made reference to this same cove as "Copper Harbour" presumably in reference to the mineralized prospect on the east side of the cove which has a low copper content. Presently, the official name is Lambton Cove and it appears so named on all government maps of the area, however the local fishermen presently refer to it as "North Cove".

Because of conflicting or confusing geographic terminology several illustrations were prepared to aid the reader in understanding the geography of the island (Figures 2, 3, 4). Figure 2 gives the official names of the geographic features, Figure 3 gives the former official geographic names which appear in older literature and still receive some local usage, and Figure 4 gives most of the common local names. Unless necessary for greater clarity of the text, the official names (Figure 2) have been used throughout this report and on the map. Where unofficial geographic names have been used, they are enclosed in quotation marks.

The derivation of the local names is often obscure but some have an interesting beginning. The following accounts are based on discussions with R. Kenney and A. King, Rossport, and J. King, Thunder Bay (1974). The Golden Slipper Mine has been so named by the local people after a yellowish-brown outcrop of Archean metavolcanic rock near the north adit at William Point which has a crude form of a slipper.

The long narrow finger of water striking southeast from McGreevy Harbour is referred to as Whitefish Bay by the older inhabitants of the region. This name is reported to have been given to the bay because it was once a site for good whitefish fishing. The bay is presently known as Pike's Bay by the numerous local fishermen that frequent the area and whitefish are not now present in the area.

Surprise Bay, which is now known as Sunday Harbour, reportedly received its name many years ago when some fishing boats from Rossport entered the bay and dropped their nets across the bay to clean the mud out of them after they had weathered a storm. In due course the fishermen raised their nets and to their surprise found them full of fish. This event is reported to have happened on a Sunday.

The origin of the name for the Slate Islands is somewhat speculative but presumably the islands were named by Captain Henry Wolsey Bayfield, Admiralty Surveyor in British North America, who in 1823 charted the north coast of Lake Superior (Cardinal, personal communication, 1975; Arthur 1973, p.52–55). The name is a misnomer since true slate does not occur on the island and the main island of the group consists of highly fissile metamorphosed Archean volcanic rocks. The highly fissile nature of these rocks causes them to break into thin tabular sheets characteristic of slate and from which the islands were undoubtedly named.

General Geology

REGIONAL GEOLOGY

The geology of the Slate Islands cannot by fully appreciated without a general understanding of their regional geologic setting. Figure 5 is a compilation of some of the more pertinent geologic features in the northeastern Lake Superior region. A prominent linear shown on Map 2199 (Ayres et al. 1970a) passing through Chipman Lake was extended south to the Killala Lake Alkalic Rock Complex on the basis of published topographic maps.

Most of the rocks exposed on the islands are Archean metavolcanic rocks belonging to the Wawa Subprovince of the Superior Province (Ayres et al. 1970b). On the mainland and north of the islands, the supracrustal rocks have been intruded by granitic rocks of varying composition (Walker 1967).

Along the west coast of Patterson Island is a small area of Proterozoic supracrustal volcanic and sedimentary rocks of the Lake Superior Basin of the Southern Province. This sequence consists of a thin unit (< 20 m) of Gunflint iron formation of Animikie age overlain by a 120 m thick sequence of Keweenawan mafic volcanic flows.

Approximately 25 km northeast of the islands lies the Proterozoic Port Coldwell Alkalic Rock Complex.

The faults beneath Lake Superior indicated on Figure 5 are from Hinze et al. (1966) who, on the basis of aeromagnetic data, interpreted the presence of two major faults in the northeastern Lake Superior Basin intersecting immediately south of the Slate Islands. These are: (1) The northeast striking Big Bay–Ashburton Bay fault; and (2) a curvilinear fault passing north of Michipicoten Island which subsequently passes immediately south of the Slate Islands, and then strikes northwest from the Slate Islands towards the town of Schreiber. That portion of the Big Bay–Ashburton Bay fault lying beneath Lake Superior has been referred to as the Thiel Fault (Klasner et al. 1982). The positions of these faults have been slightly modified from Hinze et al. (1966) by contouring of bathymetric maps published by the Canadian Hydrographic Service, Energy, Mines and Resources Canada. Contours of water depths (Figure 6) indicate that a linear trench with water depths ap-

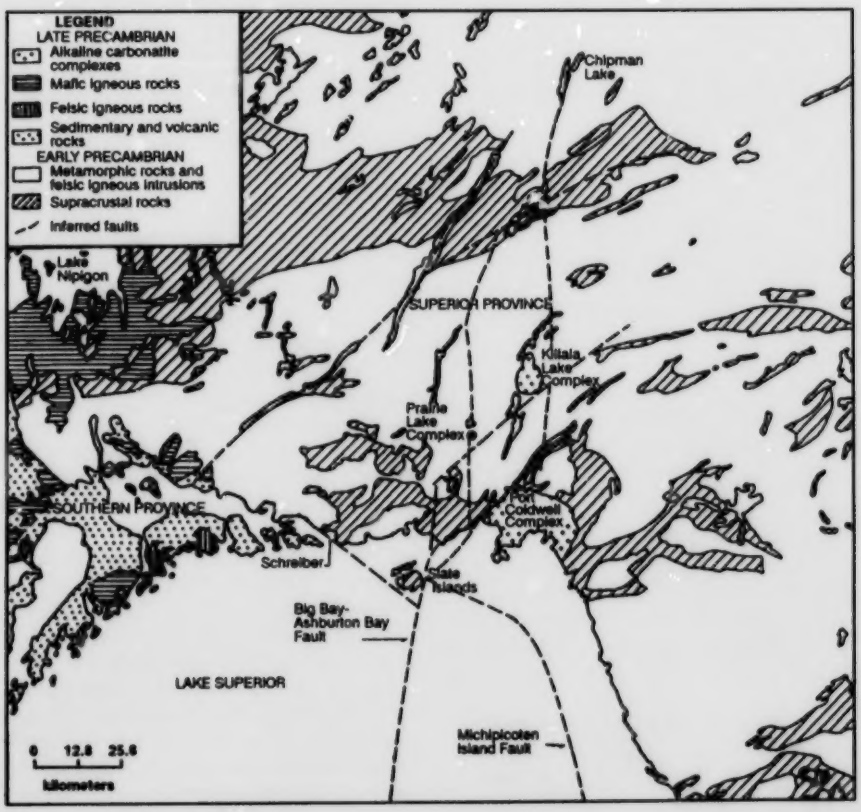

Figure 5. Regional Geology of the Slate Islands. From Ayres et al. 1970a, with additional information from Hinze et al. 1966 and R.P. Sage.

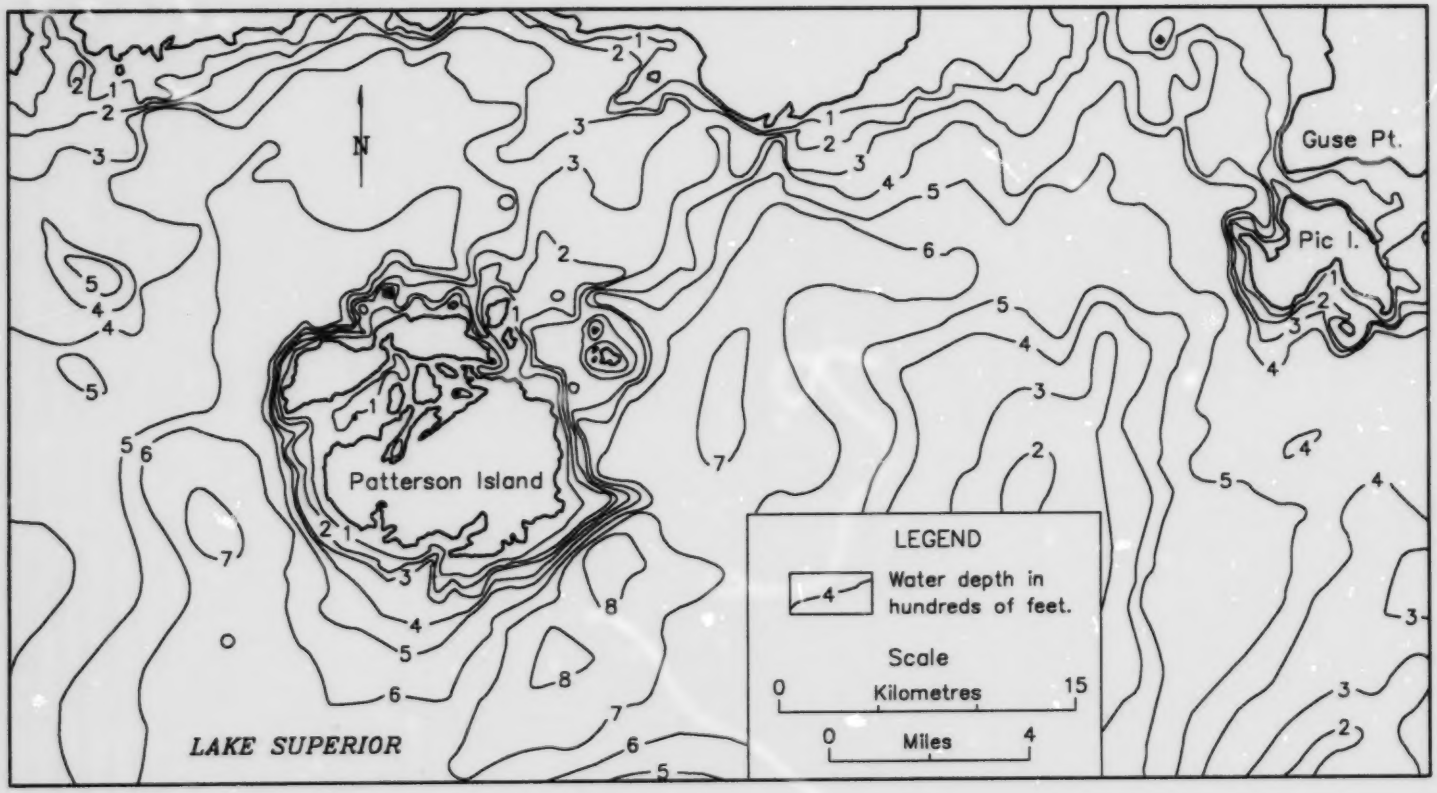

Figure 6. Water depths in the Slate Islands area.

proaching 240 m trends northeast approximately 1.5 km southeast of the Slate Islands and a similar linear trench trends northwest approximately 1.5 km southwest of the islands, parallel to the trend of the faults inferred by Hinze et al. (1966).

The on-shore extension of the Big Bay–Ashburton Bay fault, of Hinze et al. (1966) was interpreted on the basis of linear features evident on ERTS photographs (from the Canada Centre for Remote Sensing, Ottawa). Walker (1967) has noted north to northeast-trending linears on the mainland, most likely faults, at Deadhorse Creek, Santoy Lake and Prairie River. These faults are parallel or subparallel to the proposed extension of the Big Bay–Ashburton Bay fault. Walker (1967) also noted a northwest-trending set of linears which would be subparallel to the geophysically inferred Michipicoten Island fault. A trend of possible significance can be delineated by extending the Big Bay–Ashburton Bay fault north along the east side of Patterson Island. Diatreme structures are well developed along the east side of Patterson Island and the north extension would join up with Walkers (1967) Santoy Lake linear. Another linear, along the Prairie River, can be extrapolated northward to the Prairie Lake carbonatite. The Deadhorse Creek linear is the site of diatreme intrusion, and faulting is indicated by the fact that rock types do not correlate across the creek (Sage 1978a). The Big Bay–Ashburton Bay fault is a fault zone which is represented by numerous subparallel linears and faults on the mainland and geologic mapping indicates relatively minor movement (Walker 1967; Sage et al. 1976, Sage 1978a). Airphotos could be interpreted in several ways to join the linear structures north of the Port Coldwell Alkalic Complex with the Big Bay–Ashburton Bay fault and the geophysically inferred faults of Hinze et al. (1966), but only the two most prominent trends are indicated on Figure 5.

Seismic studies in Lake Superior by Smith et al. (1966) indicate that the Mohorovicic discontinuity lies at a depth of approximately 60 km beneath Lake Superior in the vicinity of the Big Bay–Ashburton Bay fault. This depth is the most extreme recorded in North America (Smith et al. 1966).

Bottom topography contours compiled by Hough (1958) indicate that the islands lie along a topographic high or ridge that crosses Lake Superior in a northeast direction from Big Bay, Michigan, to Ashburton Bay, Ontario, parallel to the geophysically inferred fault zone.

White (1972) divided the presently exposed Lake Superior Basin into five and possibly six distinctly different volcanic basins. White (1972) interpreted the western limits of the two most easterly basins to lie along the submarine ridge between Big Bay, Michigan, and Ashburton Bay, Ontario, or along the inferred fault of Hinze et al. (1966). Likewise the eastern limits of the two central basins lie along the same structural trend. This interpretation implies at least a pre-Keweenawan age for the Big Bay–Ashburton Bay structure.

On the basis of paleomagnetic studies Halls (1972) postulated that the Keweenawan Osler Group volcanic rocks pinch out towards the Slate Islands. He consequently interpreted that the islands lie along the axis of a pre-volcanic ridge.

The Big Bay–Ashburton Bay fault, associated faults, and possible extensions on the mainland may have influenced the localization of several alkalic rock complexes or areas of carbonatitic activity lying north of Lake Superior (*see* Figure 5).

Of these complexes the Prairie Lake carbonatite has been dated by Rb-Sr isotopic techniques as 1033 ± 59 Ma and 1069 ± 61 Ma (Bottriel 1975). The Rb-Sr data was revised by Bell and Blenkinsop (1980) to give 1023 ± 74 Ma and in 1987 an Rb-Sr isochron indicates an age of 1165 ± 30 Ma (Pollock 1987). The last age is considered the most reliable.

At the Port Coldwell Alkalic Rock Complex immediately northeast of the Slate Islands recent isotopic dating by Rb-Sr and U-Pb systems has been completed. Bell and Blenkinsop (1980) reported a Rb-Sr isotopic age of 1070 ± 15 Ma and Platt and Mitchell (1982b) reported an Rb-Sr age of 1044.5 ± 6.2 Ma. The merits of the Rb-Sr isotopic ages were discussed by Blenkinsop and Bell (1983) and Platt and Mitchell (1983). The isotopic age of Bell and Blenkinsop (1980) is in closer agreement with subsequent U-Pb isotopic ages. Turek et al. (1985) obtained a U-Pb zircon isotopic age of 1188 ± 56 Ma which was reinterpreted by Thorpe (1986) as 1088 ± 10 Ma. In 1987 Heaman and Machado reported a U-Pb isotopic age of 1108 ± 1 Ma. The Port Coldwell alkalic rock complex has an age of approximately 1100 Ma by either the Rb-Sr or U-Pb isotopic techniques.

Fractures and faults along the northern extension of the Big Bay–Ashburton Bay fault zone can be extrapolated through to the Killala Lake alkalic rock complex and north to the Chipman Lake fenites and carbonatite dikes. The Killala Lake alkalic rock complex has been isotopically dated by Rb-Sr isotopic techniques as 1098 ± 48 Ma (Bell and Blenkinsop 1980) and a K-Ar isotopic age of approximately 1029 ± 31 Ma has been obtained on the fenites at Chipman Lake (J.C. Baubron, Bureau de Recherches Géologiques et Minières, Orléans, France, personal communication, 1980).

In proximity to McKellar Harbour on the mainland northeast of the Slate Islands Platt and Mitchell (1982a) reported a Rb-Sr isotopic age of 1653 ± 122 Ma on lamprophyre dikes. Numerous lamprophyre dikes younger than 1100 Ma cut the 1100 Ma Port Coldwell Alkalic Rock Complex indicating one or more younger alkalic magmatic events. A minimum of three alkalic rock magmatic events occurred at the north end of the Big Bay–Ashburton Bay fault zone indicating a long-lived zone of magmatic activity that underwent periodic reactivation and alkalic magma emplacement. The Slate Islands lie on this zone of alkalic rock magmatism.

Kimberlite of Post-Ordovician age is known to occur in northern Michigan in proximity to the southern

extension of the Big Bay–Ashburton Bay fault zone (Cannon and Mudrey 1981).

The extension of the curvilinear fault from Michipicoten Island into the mainland near Schreiber may be the controlling feature for an intrusive breccia previously reported by Harcourt (1938).

SUMMARY OF SLATE ISLANDS GEOLOGY

The dominant rock group on the Slate Islands (Table 2) is composed of metamorphosed Archean volcanic rocks and subvolcanic intrusive rocks that range in composition from calc-alkalic dacite to tholeiitic basalt. These rocks have been regionally metamorphosed to greenschist facies rank and consist of coarse felsic pyroclastics, felsic to mafic tuffs, feldspar porphyry flows, volcanic slump deposits and amygdaloidal, pillowed and variolitic mafic flow rocks with thin interbedded units of argillite and siltstone. Several thin units of banded chert-magnetite iron formation are also present. This Archean volcanic sequence was intruded by Archean feldspar porphyry, quartz-feldspar porphyry and massive diorite intrusions and folded. The fold plunges at about 60° to the southwest (Sage et al. 1975). During this folding considerable tectonic adjustment took place between Mortimer and Patterson Islands and a number of smaller fold structures were superimposed on the major structure. Relatively deep water between Mortimer and Patterson Island and intense steeply dipping breccia zones along the south side of Mortimer Island suggest that faults or shearing are likely present. On the basis of pillow facing directions, an anticlinal structure forms the core of Mortimer Island.

The dominant lithologic trend of the Archean rocks is parallel to the trends on the mainland. However, locally on the islands the trend may be subparallel to the Big Bay–Ashburton Bay fault even though the fault zone regionally trends north-northeast and sharply cuts the prevailing lithologic trend. Along the west side of Patterson Island and on Bowes and McColl Islands the lithologic trend is northwest, subparallel to the suggested fault zone from Michipicoten Island which passes the south coast of the island and strikes northwest toward the Schreiber area. The dominant northeast lithologic trend lies parallel to the isoclinally folded, regional lithologic trend of the metavolcanic rocks previously mapped by Walker (1967) on the mainland to the northeast. The northwest trend along the west side of Patterson Island is likely a local feature which appears to be superimposed on this regional trend and may imply that there were two periods of Archean folding, since major deformation is lacking in the Animikie. The west coast displays two schistosity trends. One is a later axial planar schistosity parallel to the schistosity on the east coast. A second has a generally west to northwest trend which is likely a rotated schistosity, equivalent to that on the east coast.

Rocks correlated with the Animikie Gunflint iron formation occur along the west coast of Patterson Island and lie between Archean and Keweenawan volcanic rocks. The Animikie iron formation is about 20 m thick, dips approximately 50° west, lies in angular unconformity with the underlying Archean, and has been folded but lacks the penetrative schistosity which is characteristic of the Archean rocks.

Overlying the Animikie in angular unconformity is a sequence of tholeiitic, amygdaloidal to massive mafic flow rocks with local thin interbeds of red siltstone and sandstone. This sequence is approximately 120 m thick, dips 80° west in the lower portion of the section and 25° west in the upper portion. The Keweenawan rocks have been extensively sheared in the lower portion of the sequence. Halls (1974b), on the basis of paleomagnetic data, has indicated that the Keweenawan mafic flow rocks on the Slate Islands are equivalent in age to mafic volcanic rocks in the lower portion of the Osler Group farther west. Flow directions were determined on the ropy surfaces of many of the Keweenawan flows. These determinations can be considered only approximate because of the arcuate nature of the individual ridges on a ropy surface. The readings were rotated back to horizontal on a stereonet projection and plotted on a rose diagram which indicated that the source for the flow rocks was towards the east in the direction of the interior of Patterson Island. The pervasive diabase dike swarm that cuts the island is of similar age to the flow rocks and helps form some of the precipitous cliffs along the coast of Patterson Island. One large diabase dike cuts the lower but not the upper part of the Keweenawan flow sequence and some of these dikes were probably feeders for the mafic flows. Patterson Island is thus considered a likely centre for Keweenawan volcanism in which the volcanic edifice has been largely removed by erosion. Amygdaloidal mafic flow rock of Keweenawan age observed in one large diatreme structure on the southeast coast of Patterson Island indicated that typical Keweenawan flow rocks were formerly present in that area but have been removed by erosion. These diabase dikes consist of four easily recognizable types: red alkalic diabase, feldspar-porphyritic diabase, pyroxene-porphyritic diabase, and massive equigranular diabase. The latter is the dominant diabasic rock type.

A Paleozoic lamprophyre dike with carbonatitic affinities cuts across the southeast corner of Patterson Island. This dike has a maximum width of about 30 m and consists of an aligned series of apparently disconnected segments which strike northeast. The lamprophyre dike consists of olivine, phlogopite, magnetite, apatite, garnet, perovskite, and calcite in widely varying proportions. On the basis of K-Ar isotopic ages of approximately 300 Ma, the emplacement of this dike is considered to be Paleozoic in age and not coeval with the emplacement of other alkalic-carbonatitic intrusions in the region (Figure 5). The entire sequence of Precambrian rocks has been intruded by a ramifying network of diatreme breccias with a matrix containing clastic quartz grains with deformation lamellae and spatially associated shatter cone structures.

Table 2. Table of lithologic units for the Slate Islands.

CENOZOIC

QUATERNARY

PLEISTOCENE AND RECENT

Stream, lake, swamp, and beach deposits.

Unconformity

PALEOZOIC

POST-PENNSYLVANIAN

Diatreme breccia dikes[1].

Intrusive Contact

PENNSYLVANIAN

Lamprophyre with carbonatite affinity[1].

Intrusive Contact

PROTEROZOIC

KEWEENAWAN

DIABASE DIKES[2]

Massive and porphyritic diabase dikes; red alkalic diabase.

Intrusive Contact

OSLER GROUP[2]

Mafic volcanic flow rocks; thin interbeds of red siltstone and sandstone.

Angular Unconformity

ANIMIKIE

Rove Formation

Massive to poorly bedded argillite.

Gunflint Formation

Interbedded hematitic laminated argillite and chert; chert-carbonate-hematite iron formation.

Angular Unconformity

ARCHEAN

FELSIC TO INTERMEDIATE INTRUSIVE ROCKS[3]

Feldspar and quartz-feldspar porphyry, massive and schistose varieties.

Intrusive Contact

MAFIC TO INTERMEDIATE INTRUSIVE ROCKS[3]

Gabbro to diorite, massive and porphyritic; ultramafic to mafic rocks and serpentinized equivalents; basalt to dacite dikes; lamprophyre dikes.

Intrusive Contact

METAVOLCANICS AND METASEDIMENTS

Metasediments

Arkose; volcanic conglomerate; chert; chert-hematite-magnetite iron formation; argillite.

Intermediate To Felsic Metavolcanics

Dacite to rhyolite flows, locally amygdaloidal and porphyritic; tuff, flow and volcanic breccia; sericite schists.

Mafic To Intermediate Metavolcanics

Basalt to andesite flows: pillowed, amygdaloidal, variolitic and porphyritic varieties; flow breccia; volcanic breccia; tuff; porphyroblastic chlorite schist.

1. Lamprophyre dikes, dated by K-Ar techniques at 300 Ma, are cut by diatremes which are the latest major event.

2. Diabase dikes probably represent feeders to Osler volcanics and are assumed to be time equivalent. The alkalic diabase is assumed to be coeval with the Port Coldwell complex, dated at 1044 to 1225 Ma; its relation to other diabase and Osler volcanic rocks is unknown.

3. There may be more than one age of both felsic and mafic intrusions; they are believed to be largely contemporaneous with volcanism.

The islands were subsequently glaciated during the Pleistocene Epoch. The massive bulk of Mortimer Island, the Archean dioritic intrusions, and the Keweenawan diabase intrusions have all undoubtedly helped shield the more fissile Archean rocks on Patterson Island from Pleistocene glacial erosion.

The present circular shape of the main island complex (Mortimer and Patterson Islands) can be accounted for by (1) folding within the Archean sequence; (2) protection of the easily eroded schistose rocks on Patterson Island by the massive edifice of Mortimer Island and the massive Archean and Keweenawan mafic intrusions. Northwest and northeast faulting of the region would form polygonal blocks which may also contribute to the apparent circular shape of the islands at the present lake level.

ARCHEAN

Metavolcanics and Metasediments

Mafic to Intermediate Metavolcanics

Metavolcanics of mafic to intermediate composition (Unit 1) compose most of Mortimer and Delaute Islands and are similar in appearance to those mapped on the mainland by Walker (1967) and Harcourt (1938). The mafic rocks are characterized by green to dark green colour and high chlorite content. A major lithologic unit of amygdaloidal mafic metavolcanics on Patterson Island serves as a marker unit which helps define the fold structures on that island. Chemical analyses of representative samples of mafic to intermediate metavolcanics indicate that they range in composition from tholeiitic basalt to calc-alkalic basalt (*see* Appendix A).

Massive, Pillowed and Variolitic Mafic Flows. The most common mafic to intermediate rocks on Mortimer and Delaute Islands are massive basaltic to andesitic flows. These rocks are massive, fine grained, and weather green, dark green, to greenish black and occasionally a reddish brown. On fresh surface the rocks are various shades of green ranging from relatively light pastel shades to very dark. Rocks of this type are essentially absent from the other islands of the Slate Island group. In all probability some of the massive units are sills or sill-like intrusions, however unless intrusive relations were observed they were mapped as massive flow rocks. A thin section prepared from one such sample indicated that the rock was composed of fine-grained chlorite and saussurite with less than 5% very fine-grained quartz and plagioclase(?).

Along the north coast of Mortimer Island isolated occurrences of very fine-grained, medium to dark green weathering, massive metavolcanics have dark green chlorite spots. These small spots rarely exceed 3 mm in diameter and are considered to represent former mafic phenocrysts. The former phenocrysts do not exceed 5% of the rock and grain morphology suggests that they were originally amphibole.

Pillowed flows are also common on Mortimer and Delaute Islands and pillowed units were found at the southwest corner and on the northwest coast of Patterson Island. The general paucity of pillowed intermediate to mafic metavolcanics on islands other than Mortimer and Delaute must be considered as a feature of the Archean assemblage found on the islands. The intermediate to mafic metavolcanics are highly schistose on all islands with the exception of Mortimer and Delaute. Deformation, however, has not completely destroyed primary structures within the schistose rocks. The pillows range from balloon to mattress shaped; the mattress-shaped pillows are larger, having dimensions up to 1 by 2 m. Locally pillows have rare variolites along their margins and some have amygdules along their rims which may rarely reach a maximum diameter of 1 cm. The pillow selvages consist of dark green, fine-grained chlorite and generally range in width from 1 to 4 cm. The selvages weather down along the wave-washed coast and enhance the visibility of the pillow structures. The pillowed units are fine grained and commonly weather light to dark green but in several places on Mortimer Island they weather reddish tan. On fresh surfaces all the pillowed rocks are shades of green, ranging from light to dark. The reddish tan colour of some exposures may be due to the presence of a ferruginous carbonate.

In thin section the pillowed metavolcanics are composed primarily of very fine-grained chlorite and saussurite with minor amounts of carbonate. The metamorphic grade is relatively low. Two samples from Mortimer Island have relict augite pyroxene, and one has relict plagioclase of labradorite composition. Relict textures in two samples suggest that the plagioclase crystallized as radiating sheafs or as "swallow-tail" terminations perhaps suggesting that the rock was quenched (Pearce 1974). In one specimen a very fine grained mosaic of quartz and feldspar indicates that some granophyre was originally present in the rock. The relict grain morphology suggests an original subophitic, hypidiomorphic, equigranular texture with the mafic and feldspar constituents occurring in roughly equal proportions.

The pillowed units on Patterson Island are schistose and consist of very fine-grained chlorite with minor carbonate and sericite.

Associated with the distinctly massive and pillowed units are variolitic units. The massive, pillowed and variolitic rock types are gradational into each other. Variolite structures are locally common on Mortimer Island but are not present on the other islands of the Slate Islands group. Within the more massive units the variolites are often weakly segregated into ill-defined bands suggesting that a fluxion structure is present in the rocks. Pillow structures in the variolitic rocks are sometimes poorly developed. Variolites may be up to 1 cm in diameter, and in the pillowed units display a gradational change in diameter from smallest at the rim to larger towards the core where they appear to coalesce and form the pillow core. The variolites in the pillow structures range from 1 mm to over 1 cm in diameter from rim to core. One exposure of massive to very

weakly pillowed variolitic mafic metavolcanics on the south coast of Mortimer Island has variolites of 2 cm diameter. On the wave-washed shore the variolites are easily distinguished from the enclosing rock due to their circular nature and lighter green weathered surface. The variolites weather a light to medium green which in most instances stands out prominently from the darker green matrix, however those large variolites exposed on the south coast of Mortimer Island weather a reddish-brown. The fresh surface colours of the variolitic rocks are the same as the pillowed or massive mafic volcanic rocks except that the variolitic rocks are mottled in the various shades of green. One thin section was prepared of this rock type. The variolites appear to consist of altered radiating clusters of plagioclase(?) crystals. The rock is now composed of saussurite, chlorite, and minor carbonate.

Mafic Flow Breccia, Volcanic Breccia. Another very distinctive rock type which occurs on Mortimer Island is flow breccia. This rock type locally grades into poorly developed, isolated pillow breccia and broken pillow breccia. The best exposures of the flow breccia and pillow breccia are on the north coast of Mortimer Island due west of and northeast of Lambton Cove.

The flow breccia characteristically comprises 40% oblate, buff to tan coloured clasts, set in a medium to dark green chloritic matrix. The oblate clasts range up to 15 by 20 cm in size but generally are much smaller. In one exposure west of Lambton Cove a crude segregation of clasts is suggestive of flow banding or segregation.

On a slabbed surface the matrix surrounding the clasts was observed to be a very fine-grained, tuffaceous material with scattered, small, dark green chlorite spots which probably represent broken former mafic phenocrysts. In another sample, dark green lapilli sized clasts up to 1 cm in diameter occur in the matrix. The oblate buff to tan clasts are rounded to subrounded, very fine grained and contain some dark green chlorite spots of approximately 1 mm size that are probably representative of former phenocrysts. The dark green phenocrysts comprise less than 5% of the clast. The oval clasts are amygdaloidal with white, calcite-filled amygdules up to 1 cm in diameter. The clasts usually have rather diffuse boundaries with the enclosing matrix and some clasts appear to be rather highly vesiculated with very small (less than 1 mm) diameter amygdules.

A cliff face of oligomictic mafic flow breccia occurs approximately midway between Lambton Cove and Barnard Point on the south shore of Mortimer Island. The breccia comprises grey-green to greenish grey clasts set in a dark green, very fine-grained matrix. The clasts are angular to subangular and reach a maximum dimension of approximately 30 by 35 cm. The angular clasts of this unit contrast sharply with the oval clasts described above.

The matrix displays a tendency to weather down leaving the clast to stand in relief. Other minor occurrences of similar rock occur along the south coast of Mortimer Island. The mafic volcanic breccia found at "Seagull Rock" is a similar rock type although highly schistose relative to the mafic breccias on Mortimer Island.

A thin section prepared from a clast taken from the mafic flow breccia indicates that it is composed principally of very fine-grained quartz, plagioclase and saussurite, with minor carbonate and a trace of pyrite. On the slabbed surface the clasts of the mafic flow breccia were noted to contain tiny amygdules up to 2 mm diameter.

The mafic breccia at "Seagull Rock" and on the northwest coast of Patterson Island is polymictic in appearance and may be gradational into the oligomictic mafic volcanic breccia on the south coast of Mortimer Island. Breccia at these locations contains clasts with a pink to reddish tint in addition to the grey-green or greenish grey clasts. The waters of Lake Superior prevent tracing lithologic units from Mortimer Island to "Seagull Rock" to Patterson Island. The author is of the opinion that this more polymictic-appearing breccia is a facies of the oligomictic breccia and perhaps represents local slumping or development of lahars, which permitted some clast mixing. Selective carbonate alteration of an essentially oligomictic clast population could account for the colour variation in clasts, creating a polymictic appearance in outcrop. Some of the colour variation appears to be related to varying carbonate content and thus the polymictic appearance may be suspect and the Mortimer Island, "Seagull Rock", northwestern Patterson Island correlation would be more likely. The interpretation presented by the author favours this latter possibility.

At a location on the northwest coast of Patterson Island lensoid pinkish clasts up to 6 by 3 cm are set in a tuffaceous, dark green, chloritic matrix with feldspar phenocrysts or phenoclasts up to 2 mm in maximum dimension. The pink and grey-green clasts are somewhat segregated into different zones with gradational contacts.

On a slabbed surface, volcanic breccia from the northwest coast of Patterson Island appears to be composed of pink to greenish feldspar-rich clasts, some of which contain dark green chlorite spots less than 0.5 mm in diameter probably representing former mafic phenocrysts. The pink colour of the clasts may be due to carbonate alteration of the clasts. The tuffaceous matrix is a fine-grained, dark green chlorite schist.

The most spectacular occurrence of volcanic breccia occurs at the southeast entrance to Lambton Cove where the breccia is exposed in broad wave-washed areas. The distinctive pink, red, buff, and orange to light green clasts of the breccia are set in a dark green chloritic matrix. The clasts weather in relief and stand up as prominent knobs on the outcrop surface; they are generally very fine-grained and are extensively pitted from the weathering out of 1 to 3 mm carbonate filled amygdules. The pink to red clasts range up to 20 by 11 cm in size and comprise approximately 35% of the rock. The highly altered mafic clasts observed in the medium

green chloritic matrix reach a size of approximately 5 by 2 cm. A crude segregation of the clasts into bands was observed on the largest exposure of this rock type. This banding trends at a high angle to the inferred lithologic trend established in outcrop mapping and is presumed to be local phenomena related to its deposition. On a slabbed surface this unit is similar to flow breccia, however the clasts display a much sharper contact with the enclosing matrix typical of volcanic breccia. Volcanic breccia has a clearly clastic matrix which is not clearly evident in flow breccia. With a decrease in chlorite within the matrix this unit would resemble felsic flow breccia.

East of the occurrence at Lambton Cove, more poorly exposed outcrops of generally similar rock appear along the north and northeast coast of Patterson Island. Along this northern section of the coast the unit appears to be more polymictic and at one point was visually estimated to contain approximately 10% pink to red clasts with dark green chlorite spots, 40% very fine-grained basalt to andesite clasts, and 10% dark green very fine-grained clasts, all set in a medium green tuffaceous matrix. The mafic phenocrysts comprise less than 5% by volume of the oval to lensoid red felsic clasts which attain a maximum size of 21 by 14 cm. The basalt to andesite clasts are lensoid in outline and reach a maximum size of 10 by 2 cm and the lensoid dark green mafic clasts are 4 by 0.5 cm. Even though original clast shape is uncertain, the various length to width ratios in the same limited outcrop area may indicate greater deformability of mafic clasts compared to felsic clasts when subjected to essentially the same stresses. Occasionally, some of the exposures of volcanic breccia along the north coast of Patterson Island contain small (< 0.5 mm) orange-red carbonate porphyroblasts.

Flow breccia along the northeast coast of Patterson Island displays an apparent wide variation in clast compositions even though some of this variation may be due to selective carbonate alteration and weathering, imparting a polymictic appearance to the outcrop. Locally a very poorly developed clast segregation is present that could be interpreted as crude bedding. The polymictic nature and contrasting clast-to-matrix composition would suggest that this is more likely a volcanic slump deposit than a mafic flow breccia. Based on the structural interpretations of the area presented in this report, the author speculates that the exposures on the north coast of Patterson Island are correlative with those on the east side of Lambton Cove. The latter exposures, in turn, have been folded and cut out by the dioritic intrusion between Lawrence Bay and Edmonds Island and then reappear on the northwest corner of Patterson Island. However, the heterogeneity between outcrops and extensive water cover between the islands makes such a correlation highly speculative.

Along the west shore of Edmonds Island numerous boulders of carbonatized mafic breccia can be found in the surf at the approximate midpoint of the island. These boulders have a distinctive orange, orange-brown, to yellow-brown weathering of the carbonatized matrix with dark green chloritic clasts. On a sawn surface the clasts were noted to have carbonate-filled amygdules up to 2 mm in diameter and flame-like outlines. An occasional grain of pyrite up to 5 mm in size was noted. The rock comprising the boulders appears to consist of a relatively large proportion of carbonate (approximately 20%) based on estimation of carbonate on the sawn surface and from its weathering characteristics. The carbonate is possibly ankerite.

Along the southwest coast of Patterson Island volcanic breccia is infolded with pillowed mafic metavolcanics (Photo 1). The amplitude of the shear folds are 1 to 2 m. The clasts are light grey green to buff, lensoid in outline and up to a maximum of 20 by 5 cm in size. The clasts are interpreted to have been originally angular in outline but deformation has developed a more lensoid appearance. The clasts range from 1 to 50% or more of the rock but good bedding or stratification is not apparent. The clasts are generally very fine grained but some have tiny 1–3 mm amygdules. Several clasts display faint thin reaction rims 1.0 to 2.0 mm wide. The matrix of this breccia unit is a chloritic dark green tuff. On a slabbed surface a grey fine-grained chert clast 1 by 3 cm in size was noted.

The contrasting clast and matrix compositions suggest that this unit is either a slump deposit or possibly a flow breccia that has incorporated some extraneous material. Of these two possibilities the generally polymictic nature or variable clast content, and the presence of the chert clast would suggest that the first choice is more probable.

Mafic breccia also occurs along the south coast of Patterson Island, at Horace Point and Sunday Harbour. At Horace Point the unit is approximately 100 to 130 m wide and traceable along strike for approximately 500 m. The clasts are oblate in form with length to width ratios of approximately 2:1. This unit is particularly noteworthy for its bright red ovoid clasts which are set in a dark green, tuffaceous matrix. The clasts are very fine grained and composed mostly of very fine-grained, possibly plagioclase feldspar. Some clasts are porphyritic with tiny (less than 0.5 mm), feldspar phenocrysts making up approximately 1% of the clast. The weathered surface indicates that in some clasts small (1 mm) quartz phenocrysts are present in amounts of less than 1%. Clasts up to 2 by 1 m in exposures in the small bay immediately north of Horace Point appear to decrease in size southward around the point. The bright red clasts are somewhat mottled even though their composition is not expected to vary much between clasts. Some fine-grained, green clasts are also present and are probably of intermediate to mafic volcanic composition. Some very fine-grained, dark green mafic clasts are present in the dark green tuffaceous matrix. The polymictic character of this unit suggests that it is a slump deposit. If one assumes that clast size is indicative of vent proximity then the large size of the clasts here suggests that it is relatively proximal to its source. Other coarse breccias (*see* "Intermediate to Felsic Metavolcanics") on the

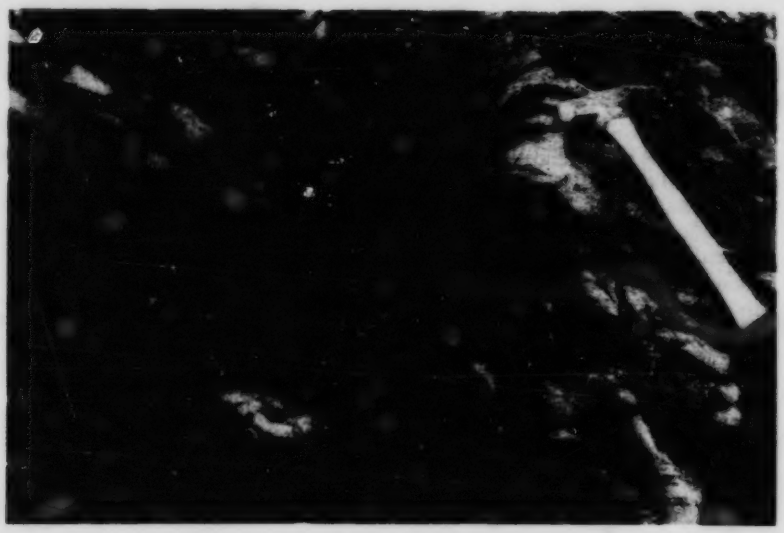

Photo 1. Mafic volcanic breccia consisting of intermediate to mafic clasts in dark green chlorite (tuffaceous) matrix. Note folding and associated clast deformation. Location P5.

south side of Patterson Island also imply that some breccias on Patterson Island are proximal to a vent site.

Chlorite Schist, Porphyroblastic Chlorite Schist. Associated with the mafic metavolcanics on Patterson Island and occurring as relatively thin units within the more felsic metavolcanics are zones of chlorite schist of volcanic origin. These schistose rocks lack evidence of primary textures but are interpreted by the author to be predominantly tuffs. On weathered surface these rocks weather green, greenish black, to grey black and on fresh surface they range from medium to dark green. With increasing sericite content this unit grades into chlorite-sericite schist which in turn grades into sericite-chlorite schist of the felsic to intermediate metavolcanics.

Along the north and east coast of McColl Island mafic schist is carbonatized and weather reddish to rusty green, in contrast to the medium to dark green of the Mortimer Island massive metavolcanics. On fresh surface the McColl Island rocks are medium green and display plumose to conical fracturing on the broken surface. The rock has the characteristic dark green of chlorite.

Along the northwest coast of Patterson Island, dark green chlorite spots up to 5 mm in diameter occur in chlorite schist along with occasional reddish orange carbonate porphyroblast of less than 0.5 mm in diameter. The spots generally do not compose more than 5% of the rock and are presumed to represent former mafic phenocrysts. In thin section this unit was noted to contain sericite, plagioclase, carbonate, chlorite and leucoxene. The rock is very fine grained, granoblastic, equigranular, with interdigitating or lobate grain boundaries. This schist is a more altered and deformed variety of the massive metavolcanics, both of which are considered to be originally porphyritic mafic flow rocks.

Along the east coast of Patterson Island and at scattered locations along the northeast coast, chlorite schists of presumed volcanic origin contain tiny (less than 0.5 mm), orange-red, carbonate and/or feldspar porphyroblasts. These colourful porphyroblasts are very distinctive and locally may comprise 20% of the rock. In one of the occurrences on the east coast, contact metamorphism may have been a factor in the development of these porphyroblasts since the porphyroblasts appear to be spatially arranged marginal to the massive quartz-feldspar porphyry intrusion exposed in scattered wave-washed outcrops on the coast. An occurrence of porphyroblasts on the northeast coast of Patterson Island appears to be spatially associated with the emplacement of a diabase dike and thus may be a contact metamorphic phenomena. Such reddish brown carbonate porphyroblasts are common in the supracrustal rocks of the Wawa area (personal observation) and no clearly demonstrated relationship exists between the porphyroblasts and intrusions; therefore such a relationship on the Slate Islands is likely fortuitous.

Much smaller exposures of this porphyroblastic rock type which do not show any obvious relation to intrusive events are present along the east and northeast coast. Most of these porphyroblastic units are very thin and are not shown on the accompanying map.

Amygdaloidal Mafic Flows, Porphyritic Flows. On the west coast of Edmonds Island and forming a distinctive unit within the interior portion of Patterson Island is chlorite schist with prominent ovoid clots of quartz and carbonate. These rocks have been interpreted by the author as amygdaloidal basaltic to andesitic flows. Amygdules up to 5 cm in maximum dimension were observed but they are generally 1 cm or less in size. The amygdules are ovoid to elliptical in plan view and consist of very fine-grained white quartz and/or white, medium-

to coarse-grained carbonate. On the west coast of Edmonds Island the carbonate weathering of the amygdules is rusty suggesting that the carbonate is ankeritic. On weathered surfaces the amygdaloidal units are medium to dark green and on fresh surfaces are generally lighter tints of the same colour. The quartz-filled amygdules weather in relief which results in a distinctive spotted appearance. Those amygdaloidal rocks containing carbonate develop a pronounced pitted appearance on the weathered surface. In thin section this unit consists of a very fine-grained mixture of carbonate, chlorite, and polycrystalline plagioclase with minor quartz. The rock is granoblastic equigranular in texture.

In one outcrop on the northwest coast of Patterson Island due south of "Seagull Rock" a crude banding is caused by variation in amygdule content and is thought to represent an original flow feature of the lava.

The relatively large amygdule size in some of these rocks suggests that they were emplaced under very low confining pressures (Moore 1965, p.43). There is a general paucity of sedimentary rocks and pillowed mafic metavolcanics on Patterson Island and where present are very local in distribution. Amygdaloidal intermediate to mafic metavolcanics are scarce on Mortimer and Delaute Island, and where present the amygdules are of much smaller diameter than the amygdules in the rocks on Patterson Island.

Amygdaloidal porphyritic flow rocks occur with feldspar porphyry flow rocks on the Leadman Islands and as a major rock-unit on Patterson Island. Amygdules up to 1 cm in diameter are not uncommon and are often filled with carbonate or fine-grained quartz. The feldspar phenocrysts may be as large as 8 mm in maximum dimension and are clearly visible on both the weathered and fresh surfaces. The phenocrysts may locally make up a visually estimated 30% or more of the rock and weather grey-green, pale pink, or red. The chlorite which helps define the schistosity planes is often a mottled green and suggests that former mafic phenocrysts may have also been present. The rocks of this class are highly schistose, weather light to dark green and are light to medium green on fresh surface. The weathered surface displays the occasional clast, and thin zones of breccia suggest either thin tuffaceous layers or brecciated flow tops. The matrix of the feldspar phenocrysts is very fine-grained sericite-chlorite schist. With increasing sericite content of the matrix, this unit is gradational into feldspar porphyry flows. The dominance of chlorite over sericite in the matrix is the criteria by which the two map units are distinguished. Chemical analyses of these porphyritic flows (see Appendix A) display a variation from calc-alkalic basalt to calc-alkalic dacite. In the author's opinion this chemical variation is a function of the highly variable chlorite content of the matrix. With the development of a brecciated appearance amygdaloidal porphyritic flows are gradational into feldspar porphyritic flow breccia. In areas which have a relatively broad wave washed expanse of the porphyritic flow rock, inhomogeneities within the units indicate that sampling of a poorly exposed area may lead to erroneous classification. The highly variable ratio of sericite to chlorite in the schist matrix of the feldspar porphyries is likely the dominant factor that most greatly influences the classification of a given unit as either felsic (calc-alkalic dacite) or mafic (calc alkalic basalt). Because of its fine grained and intimately mixed nature it is difficult to visually estimate the relative ratio of sericite to chlorite.

In thin sections of the porphyritic rocks, the highly saussuritized plagioclase phenocrysts are of oligoclase-andesine composition and are set in a very fine-grained granoblastic, equigranular, groundmass of polygonized plagioclase and possibly some quartz. The schistosity planes are defined by sericite and chlorite which are highly variable in relative proportions between samples. These porphyritic flow rocks are thought to be representative of compositions of a more intermediate nature.

Mafic Tuff. Intercalated with the more common lithologies are thin units of laminated to homogeneous, schistose to massive tuff. This rock-type contains clearly discernible fragments on the weathered surface and is considered to represent local accumulations of tuffaceous material, in part reworked by water to give some of the units a laminated appearance. These units rarely exceed 20 m in thickness and generally the clasts are relatively uniform in composition. As with other mafic metavolcanics on the islands these are very fine-grained and weather various shades of green. Tuffs are principally located along the northwest, north, and northeast coast of Patterson Island.

Intermediate To Felsic Metavolcanics

Dupuis, Spar, Leadman, and Patterson Islands all contain rocks of intermediate to felsic composition (Unit 2) which are commonly porphyritic in outcrop or in thin section. The dominance of porphyritic volcanic and intrusive rock types is a characteristic feature of the felsic to intermediate metavolcanic rock assemblage on the islands. Clasts composing the fragmental rocks have been categorized by size according to Fisher (1966).

Harcourt (1938, p.7–8) described various intermediate to felsic pyroclastic and porphyritic flow rocks in the Schreiber area on the mainland but these do not appear to resemble the rocks found in the map area. Walker (1967, p.10–11) also described porphyritic felsic flow rocks, on the mainland opposite the Slate Islands, with pink feldspar phenocrysts which may be less altered equivalents of rocks similar to those on the islands. Walker (1967, p.10) reported that strongly carbonatized porphyritic volcanic rocks appear on the shoals, islets, and the Barclay Islands east of the mouth of the Prairie River and from his brief description of these rocks they would appear similar to those on the Slate Islands. These exposures lie on-strike with the formations on the islands and with a submerged ridge indicated by hydrographic charts between the islands and the mainland. Walker (1967, p.11, Photo 6) also described agglomerates with orange clasts and chlorite matrix on these offshore islands. On the Slate Islands, similar rocks were mapped as mafic in bulk composition and are described in this report as mafic volcanic breccia (Unit 1). Walker

(1967, p.10) described the pink phenocrysts in the porphyritic felsic rocks as potassium feldspar, however, all the pink feldspar phenocrysts in the Slate Islands volcanic rocks are plagioclase of oligoclase-andesine composition. The porphyritic rocks are of intermediate composition (*see* Appendix A) and do not contain sufficient potassium or silica to be classed as rhyolite.

The author, while employed with an exploration company in the Terrace Bay–Marathon area, examined felsic to mafic flow rocks on the mainland. These observations indicate that the intermediate to felsic rocks on Patterson, Dupuis, Spar and Leadman Islands represent a highly sheared, amygdaloidal and porphyritic carbonatized sequence, unlike units of similar composition on the mainland.

Felsic Flow Breccia, Volcanic Breccia. Along the southeast coast of Patterson Island, at scattered locations along the east coast and at several locations along the west coast, and at the southwest corner of Patterson Island are exposures of light grey-green, apple green, greenish pink, to greenish brown flow breccia. Fragments are block and lapilli sized (Fisher 1966). Some of the exposures along the west coast and at the southwest corner of Patterson Island are spectacular for the coarseness of the pyroclastic debris (Photo 2). Even though there is some variation in clast composition and texture, these units consist predominantly of one clast type and are thus interpreted to be flow breccia rocks. The clasts in the breccia on the southeast corner of the island are generally very fine grained but some have small (less than 1 mm) feldspar phenocrysts. At this location clasts are up to 65 by 23 cm in size but most are much smaller. These clasts are generally lensoid in plan view but some are angular. Two large samples of this rock type were collected from the southeast coast of Patterson Island and a slabbed surface was prepared to permit examination of the textures. One sample contained oblate clasts composed of approximately 5% quartz phenocrysts up to 2 mm in diameter, set in a very fine-grained matrix. The matrix enclosing the clasts is clastic debris of the same composition with some feldspar grains of less than 1 mm maximum dimension. The rock displays local fracturing and carbonate veining. The second sample contains angular, very fine-grained, apple green clasts with tiny (less than 1.0 mm) phenocrysts of feldspar that may comprise up to 5% of the rock.

A sample from a relatively narrow unit of generally similar rock on the northeast corner of the island faintly displays clasts on the weathered surface. On a slabbed surface, the sample displays a fragmental texture with lapilli-sized clasts containing feldspar phenocrysts up to 1 mm in size and composing about 5% of the rock. The matrix enclosing the clasts is of the same composition as the clasts and contains dark chloritic spots of less than 1.0 mm diameter. The schistosity planes in the sample pass without deflection through both the matrix and clasts.

Along the southwest coast of Patterson Island are schistose pyroclastics of dominantly dacitic composition (*see* samples 24, 25, Table A–2, Appendix A). The largest clast observed in these rocks is 133 by 13 cm. The rock weathers a light green to grey green and has the same colour on fresh surface. The clasts are very fine grained.

On the west coast of Patterson Island a cliff face of dacitic flow breccia (*see* samples 27, 28, Table A–2) occurs approximately 0.4 km northwest of Horace Point. The light green weathering breccia contains angular clasts up to 30 by 10 cm in size. The fresh surface of the rock is predominantly light grey-green but has a reddish brown tint. The clasts are aphanitic but contain small feldspar phenocrysts up to 3 mm in size comprising 10–15% of the clast. North of this exposure and adjacent

Photo 2. Dacite flow breccia of Archean age. Note large clast size. Location P8.

to a diabase dike and diatreme intrusion a similar breccia may be a continuation of this same unit.

On the northwest corner of Patterson Island and approximately 0.4 km south of William Point is a spectacular cliff face of felsic flow breccia. This cliff face appears to be supported by an erosion resistant diabase dike. Clasts are up to 68 by 52 cm but most are smaller. The clasts make up more than 50% of the rock. This exposure weathers reddish brown and has a light green colour on fresh surface. The clasts are subrounded to angular in outline and generally are very fine grained in appearance. A thin unit of sedimentary rock is associated with this breccia. Chemical analysis of a clast from the breccia indicates a mugearite composition which is close to dacite (*see* sample 22, Table A-2).

The clasts of the breccias are generally enclosed in a sericite to chlorite-sericite schist matrix but a few have a predominantly chlorite matrix and may be transitional into mafic volcanic breccia. These more chloritic units of intermediate to felsic breccia have been mapped as volcanic breccia and consist predominantly of red to reddish-brown and greenish-brown weathering clasts in a chlorite schist matrix. With decreasing clast density and increasingly mafic matrix the unit becomes gradational into mafic volcanic breccia. Clasts are estimated to make up over 50% of the felsic volcanic breccia; most clasts are of the same compostion and texture although there are some extraneous clasts. These units may in part be representative of pyroclastic flow rock or in part a slump deposit. If a pyroclastic flow, the flow would have to have incorporated a large quantity of mafic tuff to account for the contrasting fragment-matrix compositions. A slump deposit incorporating and mixing mafic tuff and more felsic fragments may explain the contrasting fragment-matrix composition and is favoured by the author since it appears to be the simplest explanation.

Through decrease in chlorite content of the matrix, volcanic breccia is also gradational into a breccia unit with an essentially all sericite matrix. This unit is a red-brown to red weathering pyroclastic rock, restricted to several exposures on McColl Island and the southeast corner of Patterson Island. Of the two areas the best exposure occurs on the southeast corner of Patterson Island where broad wave-washed areas allow close study of the original pyroclastic textures of the rock and at this location the unit is cut normal to the schistosity and strike by numerous quartz veins.

On a sawn surfaces, samples of this unit from the southeast corner of Patterson Island contain clasts with feldspar phenocrysts up to 3 mm and quartz phenocrysts up to 1 mm set in an aphanitic groundmass. The phenocrysts compose a visually estimated 10% of the clast. The clast matrix consists of tuffaceous debris of the same composition. On the weathered outcrop surface the occasional more mafic clast is present which often contains feldspar phenocrysts however the rock overwhelmingly contains clasts of one composition and texture. The single clast type suggests the unit may be a flow breccia.

The weathered surface of clasts within this rock are often pitted with small pits of 1 mm or less in diameter which may suggest the presence of carbonate filled vesicles. The reddish-brown to reddish weathering of this unit may be due in part to the relatively high ferruginous carbonate content of the rock.

A unit of volcanic breccia extends along the south coast of Patterson Island from Sunday Point eastward for approximately 1200 m. Clasts in ths unit are up to 40 by 30 by 18 cm and are elongated parallel (lensoid in plane view) to the schistosity. The clasts, of very fine-grained chlorite to sericite-chlorite schist, are set in a sericite-chlorite matrix containing red to pink weathering feldspar grains. The clasts make up approximately 10% of the unit.

Numerous thin sections were prepared from flow and volcanic breccia. The rocks contain from 0 to 20% plagioclase phenocrysts which vary from oligoclase to andesine in composition and are generally highly saussuritized. Several samples contain polycrystalline quartz phenocrysts in amounts less than 5%. The plagioclase occurs as both euhedral and anhedral grains some of which are obviously fractured and slightly rotated. The rocks contain 5–20% sericite which, along with 0–15% chlorite, defines the schistosity of the rock. Carbonate was recognized in all the rocks and comprises up to 20% of some thin sections. The plagioclase and quartz groundmass of the porphyritic rocks and the texture of the non-porphyritic samples is granoblastic, equigranular and very fine grained.

Felsic Tuff. Felsic tuffs are probably more abundant than indicated on the map because most of the sericite schists and similar schistose rocks are likely tuffs. Tuffs occur as relatively thin units and are generally homogeneous. The laminated variety are presumably waterlaid, and as a group are relatively scarce. The best example occurs at William Point where a folded sequence of laminated tuff is approximately 20 m thick. Several occurrences of the more homogeneous or massive tuff are present along the east coast of Patterson Island. These units are generally less than 30 m in width.

The tuffs are fine grained, schistose and weather grey-green, orange, orange-red, red and reddish-green. They have a clearly identifiable clastic texture on the weathered surface and on fresh surface are grey-green or orange-red.

A thin section of tuff from along the south coast of Patterson Island has a very fine-grained, granoblastic, equigranular texture of quartz and plagioclase with an estimated 10% carbonate and 15% sericite. The plagioclase was too fine grained to optically determine composition.

Sericite Schist, Sericite Schist with Porphyroblasts. On Spar, Dupuis, Bowes, McColl and Patterson Islands are numerous occurrences of homogeneous sericite schist. The lack of primary features in this rock prevents a more genetic classification. In several places sericite schist display a weakly visible pyroclastic fragmental texture along strike from those without any visible fragmental

texture. It is thus assumed that most of these rocks represent former felsic tuffs.

Sericite schist weathers buff, tan, reddish brown, pink or red. On fresh surface the rock is very light green, pink or pale red. In hand sample the rock is composed mainly of sericite and tiny (less than 1.0 mm) pink to red feldspar grains. Occasional small quartz grains are also present. A common feature of this rock unit is the presence of tiny (0.5 mm) reddish orange carbonate porphyroblasts, the weathering of which imparts the orange-red colour to the rocks. From its rusty weathering the carbonate is most likely ankerite.

In thin section, rocks of this unit consist of polygonized quartz and plagioclase with up to 10% carbonate and 15% sericite. The texture is very fine grained, granoblastic, equigranular.

With increasing chlorite content, sericite schist is transitional into chlorite-sericite schist which, with continued increase in chlorite content, is transitional into schistose mafic metavolcanics.

A variety of sericite schist contains quartz and/or feldspar phenocrysts in amounts more than 1–2%. The quartz and/or feldspar grains in this rock vary between 1 and 2 mm in diameter and only rarely reach 3 mm in diameter. This phase is located principally along the north and northeast coast of Patterson Island and on McColl Island.

Another variety occurs on Spar Island and at one location on the northeast coast of Patterson Island. This subunit is distinctive for its ovoid quartz with minor associated carbonate clots which on Spar Island are up to 1.5 cm in diameter. Other than these ovoid clots which weather in pronounced relief, no other feature is present to indicate the original nature of the rock. The ovoid clots consist of very fine-grained white quartz. These ovoid quartz clots are thought to represent former quartz filled vesicles which have resisted the shearing that has so pervasively penetrated these rocks and obliterated other primary textures.

Another variety of sericite schist contains well developed chloritoid and carbonate porphyroblasts. This rock weathers the usual buff, pink or orange-red but has a distinctive spotted appearance caused by dark green chloritoid porphyroblasts. These porphyroblasts are up to 5 mm in maximum length and may compose up to 35% of the rock. The rock also has distinctive orange-red carbonate porphyroblasts up to 1 mm in maximum size. These carbonate porphyroblasts are common in sericite schist and may be considered one of its characteristic traits. In chloritoid porphyroblastic schist they are of additional interest since the carbonate porphyroblasts become completely enclosed in the larger chloritoid porphyroblasts which imparts a distinctive orange-red spotted appearance to these larger chloritoid crystals. This porphyroblast relationship suggests that the chloritoid porphyroblasts developed after the orange-red carbonate porphyroblasts and that perhaps the rock has undergone two periods of greenschist grade regional metamorphism. Some of the carbonate porphyroblasts are harder to scratch with a pen knife than would normally be expected of a pure carbonate mineral. Thus some are undoubtedly composed in part of very fine-grained quartz and/or feldspar. The best exposure of chloritoid porphyroblastic sericite schist is located along the southwest coast of one of the larger bays on the northeast coast of Patterson Island. The outcrops at these locations occur at water level and are very fissile. Fractures on the weathered surfaces of samples of this unit displayed a distinctive orange-red discontinuous veining up to 1.5 mm wide which is interpreted as being the result of weathering of carbonate along fractures. The rusty colour of the weathered surfaces suggests that the carbonate is ankeritic.

The presence of chloritoid may be more extensive than the accompanying map would indicate. Locally along the east coast of Patterson Island, samples of sericite schist contain dark spots less than 1 mm in size. This small dark green mineral was routinely noted as chlorite in the field notes. These units were of narrow width and widely scattered, but presumably more detailed sampling and thin section study might disclose that a number of these are chloritoid rather than chlorite.

The field identification of the chloritoid found at the bay on the northeast corner of Patterson Island was confirmed by X-ray diffraction by W. Hicks, Geoscience Laboratories, Ontario Geological Survey. A brief examination of a thin section from this unit indicated that the rock consists of 10–15% sericite, 25% chloritoid, 20–30% carbonate and the remainder is a fine-grained mixture of polygonized quartz and plagioclase. The texture of the quartz and plagioclase is very fine grained, granoblastic, equigranular. The chloritoid porphyroblasts were also noted in thin section to contain smaller carbonate porphyroblasts(?) confirming the field observations.

Felsic Flows. Flow rocks of intermediate to felsic composition display some textural variability. Along the west shore of Patterson Island, two isolated outcrops of massive to weakly brecciated felsic metavolcanics display discontinuous streaking which was interpreted as flow banding. These exposures weather reddish brown and are reddish grey-green on fresh surface. The rock is very fine grained and the bands have diffuse boundaries and are gradational into each other. The banding is on a scale of centimetres.

At a location on the west coast, at a second location on the northeast corner of Patterson Island, and also on the McColl Island a homogeneous, schistose, intermediate to felsic rock has dark green chlorite spots. These outcrops represent another subunit of felsic flow rocks. The rock weathers light grey green, orange, buff, tan or pinkish and is very fine grained. On fresh surface it is light green to orange-brown with dark green chlorite spots which may be as large as 3 to 4 mm. The dark chlorite spots comprise up to 10% of the surface area of the plane of schistosity but they generally comprise about 5% or less of the total rock. These spots are thought to indicate the former presence of mafic phenocrysts, and

from the homogeneous appearance of the rock, the original rock may have been a porphyritic flow. Since the chlorite clots occur on the schistosity planes a metamorphic origin cannot be discounted. However their restriction to rocks of a non-fragmental appearance and the presence of similar appearing, morphologically recognizable, chloritized, mafic phenocrysts in association with various feldspar porphyry flow rocks suggests that they are former mafic phenocrysts in flow rocks lacking feldspar phenocrysts.

In thin section this rock consists of 10–15% sericite, 15–20% carbonate, 0–5% chlorite, and the remainder is polygonized quartz and plagioclase. The texture of the quartz and plagioclase is very fine grained, granoblastic, and equigranular.

Along the southeast coast of Patterson Island felsic flow rocks are gradational into flow breccia and tuff. The flow rocks are massive to schistose, weather grey white, very light green or very light pink and are very fine grained. Fresh surfaces are the same colours. The flow rocks are tough to break, siliceous and contain zones of sericite schist. While the flow rocks are generally homogeneous, in several wave washed areas along the southeast coast they grade almost imperceptibly into distinctly clastic rocks. Clasts up to 10 by 20 cm were noted.

A thin section of this rock contains 5–10% small (less than 1 mm) phenocrysts of saussuritized, weakly zoned plagioclase of andesine composition. These microphenocrysts are set in polygonized quartz and plagioclase which is very fine grained, granoblastic, equigranular. In addition, the matrix of the rock contains 10–15% sericite and 5–10% carbonate.

On shoals along the east coast of Leadman Island are exposures of reddish brown weathering, very fine grained, massive but highly fractured felsic metavolcanics. The unit displays no primary textures to indicate the nature of its origin and has been arbitrarily classed as a flow rock. On fresh surfaces it is light grey green to reddish brown. On both fresh and weathered surfaces, pinkish feldspar phenocrysts up to 1 mm in size are visible.

In thin section this rock consists of a very fine-grained, granoblastic, equigranular, polygonized mixture of quartz and plagioclase with up to 10% carbonate, 10–15% sericite and a trace of pyrite.

Feldspar Porphyry Flows and Breccia. One of the major rock types on the islands is feldspar porphyry flows. The author has not observed such units in other greenstone assemblages and considers the volume and distribution of this rock type to be somewhat unique to the islands. The feldspar porphyry flows define a distinct horizon stretching from Leadman Island to the northeast coast of Patterson Island, south of west to McGreevy Harbour, then southwest around the south end of Lawrence Bay where it is folded into a mainly north trend and extends to the northwest coast of Patterson Island. Rocks of this type have been subdivided into two units: flows and breccia, which are completely gradational into each other. The matrix enclosing the feldspar phenocrysts of these porphyries is sericite schist to chlorite-sericite schist. With increasing chlorite content these units grade into mafic, feldspar-porphyritic flows and breccia.

The porphyry flows and breccias are distinctly different from the intrusive feldspar porphyries of Unit 5. The differences are: (1) feldspar phenocrysts are present in the flows in amounts up to 50% or more, (2) the presence of breccia units and (3) the ubiquitous presence of quartz and carbonate filled amygdules. On Leadman Island amygdules up to 1 cm are common and quartz-filled; former gas cavities up to 10 cm in diameter were observed. On the northeast coast of Patterson Island amygdules 6 by 2 cm are present, and in McGreevy Harbour amygdules up to 2 and 3 cm were observed. Several of the amygdules at McGreevy Harbour have dark green chloritic rims 1–2 mm thick that enclose the carbonate fillings. On the northwest coast of Patterson Island amygdules up to 4 to 5 mm were observed in some of the breccia fragments. The relatively large size of these amygdules suggests that this unit was emplaced under conditions of very low confining pressure (Moore 1965, p.43). The vesiculated nature of the unit and the lack of closely associated sedimentary rocks suggests that this unit may have been emplaced subaerially.

This unit is best exposed on Leadman Island where broad expanses of wave washed rock are available for study. Along the north coast of this island, obviously brecciated horizons grade almost imperceptibly into non-brecciated material. These units are most likely flow breccias or flow top breccias.

The more massive units display a distinctly colour mottled appearance due to variation in chlorite content of the matrix. This variation in chlorite matrix crudely defines ovoid structures up to and exceeding 1 m across that resemble pillow structures. The ovoid structures are outlined by a dark green, chlorite-rich matrix enclosing a pinker, more sericite-rich matrix of the ovoid centers. No sharp contacts exist between or within the ovoids nor do the relative proportions of feldspars appear to vary significantly between the sericite-rich cores and more chlorite-rich margins. The definition of these ovoid structures depends on the variation in chlorite and sericite contents of schistose matrix. On Leadman Island one massive feldspar porphyry layer is traceable across the island and is, in all probability, a thick flow center.

The most spectacular occurrence of this unit as a breccia is on the northwest coast of Patterson Island where boulders and outcrops of this breccia display a pronounced degree of concentric alteration of the clasts. As many as four rings were counted on one clast and they may reach 1 cm in width. Clasts at this exposure are up to 38 by 24 cm and one or two suggest a weakly developed flow banding.

The feldspars within this porphyry weather orange-red, pink, pinkish green, yellow to orange-brown and brown and impart to this rock its distinctive colour. On fresh surface the rock is various shades of light red, pink, or green. The feldspars are extensively saussuritized and one sawn specimen suggests that some were origi-

nally zoned and that some phenocrysts were crystal clusters and thus glomeroporphyritic. The feldspars are up to 8 mm in maximum dimension and seriate in distribution. Along the schistosity planes dark green chlorite clots suggest that mafic phenocrysts were formerly present and the grain morphology of one clast sample from the northwest coast of Patterson Island suggests that it was originally hornblende. These dark chlorite clots are up to a maximum of 6 mm in diameter. On the basis of grain morphology the author considers it unlikely that these chlorite clots are solely metamorphic in origin but represent chlorite replacement of former mafic phenocrysts under greenschist facies conditions of regional metamorphism.

The weathered surface of large exposures of this rock type are typically mottled in various shades of pink, green and orange-brown, and if amygdaloidal, this surface will also have white spots from the weathering out of the quartz-filled vesicles or a pitted surface if the vesicles were carbonate filled. On fresh surface the rock is mottled in various shades of the same colours and may contain very fine-grained white quartz or coarse-grained, white carbonate clots if amygdaloidal.

In thin section, relict portions of the saussuritized feldspar phenocrysts were determined by optical techniques to be andesine. The phenocrysts, in addition to albite twinning, locally display Carlsbad twinning. The crystals are often broken, weakly zoned, commonly glomeroporphyritic, seriate in size distribution, and generally extensively altered to sericite and carbonate. The chlorite in the matrix to the phenocrysts occurs as lensoid clots and could be interpreted as either former tuff fragments or as deformed mafic phenocrysts. The matrix also contains 5–10% carbonate, 5–20% chlorite, 10–20% sericite, and the remainder consisted of polygonized quartz and plagioclase. The polygonized quartz and plagioclase of the matrix is very fine-grained, granoblastic, and equigranular.

Chemical analyses of these feldspar-rich flow rocks indicate a composition varying from calc-alkalic basalt to calc-alkalic dacite (*see* samples 33–38, Table A-2). The wide range in composition is likely due to variations in the chlorite-sericite ratio in the matrix.

Metasediments

Archean sedimentary rocks (Unit 3) are of relatively local distribution on the islands. The metasediments are predominantly volcanoclastic and probably of local derivation. The metasediments cannot be traced laterally for any great distance and appear to interdigitate with volcanic units. The finer-grained, bedded deposits may represent local interflow basin accumulations while the more polymictic, poorly stratified units may represent epiclastic slump or laharic mudflow deposits.

Volcanic Conglomerate, Arkose. One of the more noteable units on the island is volcanic conglomerate. This is a polymictic and unstratified unit composed principally of volcanic rock clasts which commonly contains clasts of very fine-grained, red or grey-white chert. The distinction of some volcanic conglomerate units from associated volcanic breccia units is based solely on the presence or absence of chert clasts. In some cases units displaying a large variety of clast types with or without evidence of crude bedding, have been mapped as volcanic conglomerate to separate them from flow breccia units. Volcanic conglomerate occurs midway along the east coast, and at William Point, and east of McGreevy Harbour on Patterson Island.

The unit at William Point is perhaps the most spectacular. Near the old mine adits the conglomerate contains bright red, finely laminated, angular chert clasts which are very colourful in the wave washed outcrop along the beach. Associated with this volcanoclastic conglomerate is massive to poorly bedded arkose. The arkose was only observed on the northwest corner of Patterson Island and is reddish brown weathering and structureless except for a secondary schistosity. Associated with the arkose are two lenses of iron stained, bedded chert (not shown on map) of approximately 15 by 2 m into which the two adits on the northwest corner of Patterson Island were collared. The rugged and exposed nature of the coast at this point makes examination very difficult but possible stratification and grain gradation in the arkose indicate tops to the northeast. Extrapolating from the field notes of G.E. Parsons, consulting geologist, who worked on the islands in 1960–1963 for the Kimberly-Clark Company Limited, a red banded chert layer lies immediately offshore at this point. The abundance of red laminated chert pebbles in the beach gravels along this portion of the coastline supports this conclusion. The chert cobbles in the volcanoclastic conglomerate are of similar appearance which suggests that they were derived from the chert unit lying offshore and that the chert unit is thus older. This line of reasoning would indicate tops to the northeast as suggested by the arkose unit. Clasts make up about 30% by volume of the conglomerate; the relative abundance of clast types is about 44% mafic volcanic, 54% felsic volcanic and less than 2% chert. The clasts are up to 10 by 5 cm in size and angular to subangular in shape. The arkose associated with the conglomerate was examined in thin section and was estimated to contain 5–10% chlorite, 10 to 15% carbonate, 10–15% sericite, 5–10% limonite, 25% quartz, and 35% saussuritized plagioclase. The rock has been recrystallized and texturally is fine grained, granoblastic equigranular. The sericite and chlorite likely represent former matrix.

On a slabbed surface of the volcanoclastic conglomerate most clasts are grey-green in colour and mafic to intermediate in composition. Other clasts are pink and composed primarily of feldspar. Several clasts have amygdules up to 3 mm in diameter.

Another conglomerate unit is present on the northeast coast of Patterson Island and while chert clasts are lacking, the polymictic nature of the unit suggests that it is a volcanoclastic conglomerate. This unit appears to be gradational into mafic volcanic breccia. The clasts are subangular to lensoid in outline.

At the location on the northeast coast, in a wave-washed exposure approximately 30 by 10 m, clasts constitute about 30% of the rock and the clast population consists of approximately (1) 5% very fine-grained, grey to pink felsic clasts up to 48 by 21 cm; (2) 5% light greenish grey felsic clasts up to 60 by 20 cm; (3) 10% medium green very fine-grained intermediate clasts up to 43 by 23 cm; (4) 30% medium to dark green, very fine-grained, mafic clasts up to 14 by 20 cm; and (5) 3–4% amygdaloidal feldspar porphyry clasts with quartz-filled amygdules up to 7 mm and a maximum clast size of 16 by 7 cm. The clasts weather varying shades of green, pink, and red. The matrix weathers a medium to dark green and on fresh surface is a dark green. The matrix appears to consist of a mixture of volcanic debris.

On a slabbed surface of a large specimen of this volcanic conglomerate, a polymictic clast population is enclosed in volcanic detritus of similar material. Several of the grey-green clasts and several of the pink, more felsic clasts had dark green chlorite spots less than 0.5 mm in size which, based on morphology of the spots, represent former mafic phenocrysts. The matrix of this sample also contains reddish brown spots about 0.25 mm in diameter which are thought to be carbonate porphyroblasts of ankerite composition.

Along the east coast of Patterson Island several units of volcanic conglomerate contain rare chert clasts. These units are not as polymictic as the occurrences described above but contain very fine-grained, grey-white chert clasts. These chert clasts are not present throughout a unit and generally never exceed 1% by volume of the rock. Three separate units were identified and these are intercalated with a sequence of quartz-feldspar porphyry and feldspar porphyry intrusive rocks, felsic flow breccia, sericite schist and mafic tuff. The chert clasts range from subangular to subrounded in outline. Sharp angular clasts and well rounded clasts were not observed. The most southern of these units contains blue-grey, fine-grained chert clasts up to 12 by 5 cm over 15 m of the unit's 50 m width.

The second unit, which is about 32 m thick, contains similar chert clasts up to 11 by 2 cm in size and in small scattered areas of the exposure the chert clasts may comprise about 5% of the rock.

The most northern of the three units is about 60 m wide and along its southern contact contains grey-white chert clasts up to 1 by 4 cm in size. Chert was not detected in this unit northwards along the beach, but a black fine-grained, laminated chert unit approximately 1 m thick is present in the middle of the conglomerate. Along the north contact of the conglomerate, chert clasts are again present up to a maximum size of 25 by 17 cm. Where observed, the chert clasts comprise less than 1% of the rock.

On a sawn surface of a sample of this unit, angular volcanic rock clasts are set in a matrix of clastic volcanic debris. One clast has a 2 to 4 mm wide reaction rim and one small dioritic clast is heavily impregnated with pyrite. The lack of reaction rims on essentially all the remaining clasts suggests that the alteration rim was formed prior to incorporation in the conglomerate. Small (less than 0.5 mm), dark chloritic spots in some clasts suggest former mafic phenocrysts which have been replaced by chlorite. The restriction of the chlorite spots to clasts implies that the spots represent former phenocrysts rather than porphyroblastic development which would also be expected to occur in the matrix. The sample is fractured and veined with carbonate.

On casual inspection these units could easily be interpreted as volcanic flow breccias and without the benefit of extensive wave-washed exposures would be most likely mapped as such.

On Shell Island, a slump breccia deposit is associated with chlorite-sericite schist and massive felsic to intermediate flow rocks. This unit lacks chert fragments but its polymictic nature suggests that it is volcanic conglomerate. The matrix of this breccia weathers tan and has weakly developed, thin bedding (about 1 cm). The breccia clasts are angular to subangular, the largest being of pinkish felsic metavolcanics up to 1 m by 40 cm. Light green, intermediate metavolcanic clasts, fine-grained, mafic clasts and mafic clasts with feldspar phenocrysts up to 6 mm are also abundant. One of the larger felsic clasts shows weakly defined flow banding (about 1 cm thick bands). The matrix consists of volcanic detritus which appears similar to the clasts in composition. The rather large clasts in this unit suggests that it is proximal to its source area.

Another possible volcanic conglomerate is exposed in a small bay approximately 750 m southwest of Pearl Island on the southeast coast of Patterson Island. Exposures at this location contain 35–40% clasts up to 50 by 15 cm in size. These clasts are elongated parallel to schistosity and chert clasts were not recognized. The clasts consist of grey-white, very fine-grained, felsic to intermediate metavolcanics; brown, fine-grained, mafic metavolcanic clasts and intermediate composition feldspar porphyry clasts with some 5 mm quartz phenocrysts. The clasts are highly attenuated with a length to width ratio of 5:1. The matrix is clastic feldspathic sericite schist. Some massive pyrite occurs along the contact of this unit with a mafic unit to the south.

Iron Formation and Chert. Iron formation occurs in limited amounts on Patterson Island. One exposure of iron formation occurs on the northeast coast of Patterson Island and the abundance of iron formation detritus along this section of the beach suggests that the unit extends for some distance eastward under the water. One water-surrounded outcrop beneath a cliff face at the very tip of a point of land consists of very highly contorted, magnetic, grey, red and reddish brown layers of chert (quartz) which are finely laminated on a 1 mm scale, alternating with blue-grey, metallic-looking, magnetite-chert layers. The chert-magnetite layers are highly contorted and vary from 1 to 6 cm in width. The fine laminations occur only in the red to red brown chert beds which vary from 1 to 2 cm in width compared to the unlaminated, structureless, grey chert beds which vary from 1 to 6 cm in width. The iron formation at this loca-

tion appears identical to the iron formation clasts in the beach gravels along the coast immediately north of the exposure.

The iron formation is cut by a very irregular, fine-grained, Archean mafic dike which has milky quartz-filled tension gashes normal to its irregular strike. Samples of this dike display a conical fracture pattern suggestive of shatter cone structures. These strike N65°E, plunging 10° northeast towards an extrapolated trend of diatreme breccia dikes that extend in a north direction off the east coat of Patterson and Dupuis Islands. This area displays extensive shearing and some faulting is suggested since the outcrop lying offshore appears displaced northward relative to an exposure of iron formation that outcrops along the beach. At the exposure on the beach the iron formation consists of banded grey chert and fine-grained chert-magnetite in widths up to 10 cm. The unit is 6 to 7 m wide and appears to strike approximately N65°E with a vertical dip. The unit is strongly magnetic and can be traced west-southwest from the east shore to just north of "Stinking Lake" where it abruptly changes strike to south-trending. The unit may undergo a facies change or pinch out beyond this point for it cannot be traced on the basis of aeromagnetic data nor was it encountered in outcrop. The presence of this continuous unit of iron formation suggests that the feldspar porphyry unit, north and south of the unit are thick massive flows rather than sill-like intrusions as presented here.

Another occurrence of iron formation is located on south Patterson Island west of Sunday Harbour. The general east trend of this unit is apparent on aeromagnetic maps of the area. This iron formation is about 18 m thick and is the thickest unit of iron formation observed on the islands. It consists of alternating bands of very fine grained quartz (chert) and magnetite and weathers brown to rusty brown. The bands of magnetite are 3 to 25 mm thick. The weathered surface displays some differential weathering suggesting the presence of thin bands and lamellae of argillite.

The general distribution of outcrops in this area suggests that either more than one unit of iron formation is present or that one unit has been complexly folded. The latter interpretation is preferred.

A thin section prepared from this unit contains 20% magnetite, trace carbonate, 25% chlorite, 10% very fine-grained stilpnomelane or biotite and 40% quartz. The chlorite probably represents thin beds of very fine grained mafic volcanic detritus washed into the basin where the iron formation was being deposited. The magnetite, chert, and argillite laminations are on the order of 0.1 to 4 mm thick, and quartz (the recrystallized chert) is very fine-grained, granoblastic, equigranular. Several outcrop samples weakly soil the fingers with a dull grey, graphitic-like coating, suggesting that graphite may be present.

A bulk sample from this unit was assayed. Equal volumes of iron formation were chipped at 0.3 m intervals over a width of 17.4 m and submitted for assay to the Geoscience Laboratories, Ontario Geological Survey. The assay returned 56.9% silica, 18.5% iron, 0.18% phosphorous pentoxide, 0.02% sulphur, 0.19% titanium and 0.01 ounces per ton gold.

Aeromagnetic data suggests that a unit of iron formation is associated with mafic volcanic breccia just east of the small bay east of Horace Cove. This unit was not seen in outcrop during this survey but its presence is inferred from compiled outcrop data (G.E. Parsons, consulting geologist, Toronto, personal communication) and aeromagnetic maps.

On the southwest coast of Patterson Island about 700 m west of Horace Cove an isolated outcrop of iron formation forms a small offshore shoal. This one exposure consists of iron formation very similar to that on the northeast coast of the island. The unit is highly brecciated and the banding in the chert fragments is prominent. Banding varies from 3 to 15 mm thick and consists of alternating recrystallized chert and magnetite layers. The chert weathers brown, grey, red and orange-brown and the magnetite-rich layers are black. This exposure resembles the brecciated iron formation reported by Parsons (1918, p.163, Figure 11).

The field notes of G.E. Parsons, consulting geologist for Kimberly–Clark Company Limited, indicate a northwest-striking band of cherty "iron formation" between Horace Cove and William Point. This unit was not observed in outcrop by members of this field party but the abundant red banded chert pebbles found on the northwest corner of the island are probably derived from the submerged extension of this unit. The very low iron content and the fact that aeromagnetic surveys of the island were flown roughly parallel to the strike of the formations in this part of the island makes it difficult to interpret the possible extent of this unit.

Pebbles presumably from this unit, picked up on the beaches along the northwest coast of Patterson Island, consist of highly fractured, very deep red, very well laminated chert. The laminae vary from 0.1 to 3 mm in width. The presence of similar chert clasts in the volcanic conglomerate exposed on the beach near the old adits is considered to indicate that the conglomerate is younger than the chert unit and thus stratigraphic tops are towards the northeast. This was the most reliable stratigraphic top indicator found on Patterson Island. The red banded chert clasts make up less than 1% of the volcanic conglomerate and the relative abundance of the chert fragments on the beach implies a source other than weathering out from the conglomerate. The source is thought to be an underwater extension of the predominantly chert unit mapped by G.E. Parsons (unpublished data) along the west side of Patterson Island.

Extending north, northeast and then east along the coast of Patterson Island from the mine adits is another occurrence of banded chert and magnetite iron oxide which is about 3.3 m wide but is complexly folded and may be thickened due to the folding. The red chert bands are up to 12 cm thick and very finely laminated. The magnetite bands are about 3 to 4 cm thick and the lack of magnetic response of some samples suggests that

the steely grey metallic mineral is hematite. This unit could not be traced into the interior of the island and its very limited exposure did not justify extensive mineralogical investigation.

Along the southwest shore of Patterson Island a unit of reddish brown, iron stained, highly brecciated chert is located in a small cove about 1000 m west of Horace Cove. Breccia clasts are up to 20 cm in size. This occurrence may be related to the iron formation located about 300 m to the southeast.

Blue-grey to buff laminated chert on the north side of Delaute Island occurs as thin, well laminated interflow units in a pillowed to massive mafic volcanic sequence. The chert bands rarely exceed 2 m in thickness and generally are much thinner. They cannot be traced for any significant lateral distance and probably represent only local accumulations of chemical precipitate in pockets on the flow surfaces. The chert weathers blue-grey, light green or buff and commonly contains finely disseminated pyrite up to 1 mm in grain size. The laminations within the chert are generally on the order of 1 to 3 mm. The laminae in general reflect a northeast trend but strike varies considerably between units and between segmented portions of the same unit which suggests that the strata may have undergone extensive tectonic adjustment.

A similar chert unit is located in the wave-washed area along the west coast of Edmonds Island. The chert unit is interbedded with tuff and weathers deep red to grey-green. It is very fine grained, massive to very well laminated and complexly folded and sheared. The exposure is cut by irregular, milky quartz stringers up to 3 cm wide. The laminae are up to 1 mm wide and are better developed in the red, hematite-rich chert bands. The green-grey chert is generally massive, rarely laminated and occurs in bands up to 8 cm thick. The unit is estimated to be 7 m thick but folding may have distorted it. The interbedded tuffs are very fine grained, reddish brown weathering, highly schistose, highly carbonatized and are not as strongly veined with the milky quartz stringers as the chert. This chert unit is located in the wave-washed surf and appears to pinch out before it reaches the shore of the island.

Argillite. Well bedded, grey-green, greenish brown, brown to black, locally iron-stained argillite occurs as interflow beds along the west coast of Mortimer Island, as deformed or folded units along the south coast of Mortimer Island and as a distinctive unit on the southeast side of Sunday Harbour on Patterson Island. On fresh surface, the rock is black, greenish black to brownish black.

Along the west coast of Mortimer Island the argillite units are locally siliceous and highly folded, suggesting that adjustments between flow units during folding were perhaps largely compensated for in the argillite beds. These units vary from 2 to 21 m in width and bedding ranges from 2 mm to 1 cm in width. Trace amounts of pyrite were noted in some of the iron stained units.

Along the south coast of Mortimer Island a number of highly folded units of very well bedded argillite are exposed at wave level. These units have weathered and fresh surfaces similar to units on the north coast of Mortimer Island. It is not clear whether these exposures represent one dismembered unit or a number of interflow units. The location of the unit and its highly fractured and folded nature suggests that deformation between Mortimer Island and the islands to the south may have been localized in part along this argillite unit. Locally the argillite grades to siltstone and rarely to sandstone. The argillite units are estimated to vary from 6 to 15 m thick but all sections are incomplete since only one contact is usually visible. The maximum thickness of individual beds varies from 4 to 12 cm and each bed is finely laminated on the millimetre scale (usually 1–3 mm). The bands of slightly lighter green are chlorite rich and mafic in composition and the darker green bands are flinty and siliceous. At an outcrop approximately 0.4 km west of Lambton Cove argillite is cut by a mafic dike that is indistinguishable from mafic metavolcanic rocks on Mortimer and Delaute Islands.

On the east side of Lambton Cove an adit was driven in part along a pyrite-bearing argillite unit. The very fine-grained argillite unit is 2.5 m wide in the cliff face behind the adit exposure and locally pyrite makes up 50% of the rock. The pyrite is widely disseminated and locally occurs in balls or oblate concretions up to 1 or 1.5 cm in diameter. These ovoid concretions have a radiating structure and tend to have finer-grained cores and coarser-grained rims. The rims are up to 0.5 mm in width.

A thin section was prepared from a siltstone bed within the argillite unit approximately 1.2 km west of Lambton Cove. This sample was visually estimated to contain 15% quartz, 20% plagioclase (oligoclase-andesine), 10% chlorite, 10% sericite, and 45% very fine-grained mixture of quartz and plagioclase. The larger quartz and plagioclase grains are angular to subangular. The very fine-grained groundmass is recrystallized and has a granoblastic, inequigranular texture.

The argillite at Sunday Harbour appears to be a local basinal accumulation within the volcanic stratigraphy for it cannot be traced laterally for any significant distance. This distinctive unit is exposed for approximately 300 m along the north side of Sunday Point. The rock weathers grey to black and is greenish black to grey-green on fresh surface. Individual beds, up to 11 cm thick, are finely laminated. The maximum thickness of the laminae is about 4 mm. Flame structures in one exposure suggest that the stratigraphic top is towards the east. Scattered grains of disseminated pyrite are present. Towards the northeast, argillite bedding wraps around the occasional block of felsic metavolcanics up to 4 m long. Towards the southwest the unit becomes conglomeratic with whitish to buff felsic metavolcanic clasts up to 20 cm in length.

A thin section prepared from this unit was visually estimated to contain 10% carbonate, 10–15% sericite, 10–15% quartz and 70–80% fine-grained matrix of

quartz and plagioclase. The larger clastic quartz grains are subangular to angular and the matrix is recrystallized giving a very fine-grained, granoblastic, equigranular texture. Some very thin (< 0.2 mm), dark opaque laminae may represent carbonaceous beds.

A small isolated outcrop of chlorite schist near the argillite at Sunday Harbour contains large (up to 1 cm) porphyroblasts of chlorite and may be part of the argillite unit. The schist weathers brown and on fresh surface is dark green. The rock is highly schistose and very fine grained. This unit was found only at this one location and was not examined in thin section.

One of the best exposures of metasediments is on the southwest tip of Mortimer Island at Barnard Point. This unit, approximately 70 m wide, consists of well bedded lithic arkose and argillite (Photo 3) and is in sheared contact with a mafic volcanic sequence to the north. The shear zone is represented by a zone of extensive brecciation.

On weathered surface the coarser-grained and thicker beds are grey-black, grey-green to reddish brown. The thin siliceous argillite layers weather black to dark greenish black. The arkose contains feldspar clasts up to 1 cm across but generally on the order of 1 mm. Rounded quartz grains up to 2 mm are present but the average size is less than 1 mm. Locally the arkose contains rock clasts; the most common is very fine-grained, black, siliceous argillite or chert. These dark clasts may reach 10 by 2 cm in maximum size but generally are much smaller. Other rock types noted are white, black, and blue-grey chert (1 to 3 cm), and buff coloured, porphyritic, felsic metavolcanics (2 to 3 cm). The volcanic clasts contain small 4 mm orange feldspar phenocrysts and several clasts display poorly developed reaction or weathered rims 1–2 mm thick.

The arkosic beds are separated by thin beds of very finely laminated, very fine-grained, black, dark greenish to brownish black argillite. The laminations in the argillite range from 0.5 to 3 mm and beds are generally less than 1 m thick. The arkosic units were generally structureless and on the order of several metres thick. They display no primary depositional structure other than possibly a poorly developed grain gradation in one exposure. The argillite beds at various locations display load casts, slumpage, cross-bedding, flame structures, graded bedding, and ball and pillow structures. In most cases these structures were only of marginal value in determining stratigraphic tops but where suitably developed, tops are consistently to the north, opposite to pillow facing directions in mafic metavolcanics north of the metasediments. This suggests that the shear zone lying along the north contact of this unit is a fault zone. The steep and sometimes overturned bedding suggests that this unit is Archean in age, however a Middle Proterozoic age cannot be discounted since less deformed Rove Formation rocks at "Caribou Point" display similar variability in bedding attitude. Arkose and siltstone are major components of the Barnard Point metasediments, however the Rove Formation displays considerably less of the coarser-grained fraction and appears to be a more mature sediment. If the Barnard Point metasediments are Middle Proterozoic they would have to be much more proximal than the Rove at "Caribou Point" to account for their much less mature nature. The minor structures found in the Barnard Point metasediments do not occur in the acknowledged Rove units with the exception of graded bedding.

Three thin sections were prepared from the arkosic units within this sequence and one thin section was prepared from an argillite bed. Other than grain size and colour, little difference in mineralogy was noted between the coarser and finer-grained fractions.

Photo 3. Interbedded argillite and arkose with minor scour channels; southwest corner of Mortimer Island. Location P15.

Visual estimates of the mode for these metasediments are 10–20% subangular to subrounded quartz grains, 60–90% saussuritized plagioclase (andesine), 0–15% carbonate, 0–10% rock fragments, predominately chert, and 0–10% very fine-grained, brownish chlorite (?). One section contains nearly 10% very fine-grained sericite, and another contains what appears to be very fine, dusty limonite. Within all sections there is a wide range in grain size with the largest grain being approximately 1.5 mm. The highest feldspar content, angularity of grains and lithic fragments all indicate an immature sediment.

According to the classification of Williams et al. (1954, p.292) the coarser-grained sedimentary rocks are volcanic wacke (greater than 10% rock fragments); by Folk's classification (1968, p.124) the rock is arkose to lithic arkose with feldspar to rock ratios of 3:1 to 1:1. Outcrop examination indicates a highly variable lithic fragment content which in thin (< 1 m) local zones may approach 20–25%. This rock type, taken as a group and based on both thin section and outcrop examination, falls in the arkose to lithic arkose categories of Folk (1968). The argillite units have the same relative mineral abundances as the coarser-grained units and identifiable rock fragments are not common. The argillite units undoubtedly had the same source area and the lack of lithic fragments is due to finer grain size resulting from more complete breakdown of the clasts.

The repeated sequence of structureless arkose with lithic fragments and well laminated argillite suggests rapid inflow of coarser-grained detritus followed by periods of quiescence in which the argillite was deposited. This process was cyclic and repeated many times. The very fine-grained, black, cherty argillite clasts found in the arkosic units are probably fragments plucked from the upper surface of a preceding arkose-argillite couplet.

The source for this detritus was most likely a felsic volcanic terrain composed in part of porphyritic felsic volcanic rocks similar to the clasts found in the more lithic portions of the arkosic units.

Mafic to Intermediate Intrusive Rocks

Archean mafic to intermediate intrusive rocks (Unit 4) form one of the more abundant rock types on the island. The larger more massive bodies of this rock undoubtedly served as protective shields during Pleistocene glaciation and inhibited the glacial erosion of the much more fissile and softer schistose volcanic rocks which they intrude. Some of the higher hills of the islands are composed of Archean dioritic to gabbroic intrusions.

Gabbro to Diorite. Gabbro is relatively rare on the Slate Islands and is mainly a mafic phase of diorite which is more common. The gabbro consists largely of chloritized and actinolitized hornblende-rich rocks.

Diorite is the most common rock type of this group. It is massive, relatively homogeneous, fine to medium grained (approximately 1–1.5 mm), weathers grey green to greenish black, and on fresh surface is a mottled dark and light green. The chloritized mafic minerals in these rocks commonly have morphologies more typical of hornblende than pyroxene and thus the rock was classified as diorite in the field. On Edmonds Island a dioritic intrusion has a peridotite phase. Rocks with a dioritic appearance in the field when examined in thin section are found to be fundamentally the same as others interpreted to be more mafic (gabbroic) in composition. On the basis of thin section examination rocks mapped as gabbro or diorite in the field were all coded as Unit 4a. Rocks in this category occur on the southeast tip of Mortimer Island, along the west coast of Lawrence Bay on Patterson Island, south and southeast of the south end of Lawrence Bay, in several bodies east of the north end of Horace Cove Patterson Island, on Edmonds Island, and north of Sunday Harbour. It is probable that some of the units mapped as mafic metavolcanics on Mortimer and Delaute Islands are sill-like dioritic intrusions but intrusive features were not found. Along the west coast of Edmonds Island, the schistosity of the metavolcanics is cut by diorite at an angle of approximately 20–30°. This diorite is more massive and less carbonatized than some other diorite units along the same shore and these differences suggest that there may be more than one age of Archean diorite.

One exposure of possible metamorphosed gabbro is closely associated with a possible ultramafic flow on the south coast of Mortimer Island. The gabbro is massive, medium to coarse grained, weathers light green to brown and is dark green on fresh surface. The unit is locally porphyritic with plagioclase laths up to 1.5 cm long and has been sheared and brecciated. While its coarse-grained nature may indicate a thick flow center, the unit is more likely intrusive gabbro.

In thin section the porphyritic gabbro is highly altered and consists of the following visually estimated constituents: 20% chlorite, 60% chloritized and actinolitized pyroxene and plagioclase, 15% interstitial quartz, and 5% leucoxene after skeletal magnetite. The interstitial quartz is locally granophyric consisting of clear quartz intergrown with chloritized and altered pyroxene.

Gabbro is also located on the north coast of Mortimer Island due south of Frank Rock. Here the gabbro is massive, highly fractured, homogeneous, equigranular, weathers a brownish green and is dark green on fresh surface. On the outcrop surface, the rock is estimated to consist of 80% altered pyroxene and 20% plagioclase. Scattered areas along the north side of the outcrop are porphyritic with up to 5% altered pyroxenes up to 5 mm in size. The outcrop is cut by numerous small quartz veins.

In thin section the rock was visually estimated to contain 80% actinolitized pyroxene, 8% chlorite, 2% quartz, 3–5% serpentine, 3–5% carbonate, and less than 1% magnetite rimmed with leucoxene. The altered pyroxene has a somewhat mottled appearance in thin section suggesting that alteration was not uniform but patchy. Although fresh plagioclase was not observed in

thin section, the rock was classified as gabbro due to the presence of altered pyroxene. Turbid, highly altered, interstitial material is likely a former plagioclase.

Along the southeast coast of Mortimer Island the dioritic intrusions locally have a porphyritic phase along their margins. The phenocrysts are pinkish weathering plagioclase crystals up to 1 mm in size which congregate into 1 to 1.5 mm clots. The plagioclase phenocrysts are glomeroporphyritic and comprise about 5% of the rock. The phenocrysts are not readily apparent on the freshly broken surface of the rock.

Thin section examination of the non-porphyritic phase indicates that it consists predominantly of equal amounts of chloritized and actinolitized pyroxene and saussuritized plagioclase. Thin section examination indicates former pyroxene as the dominant mafic mineral rather than amphibole. The extensive replacement of the pyroxene by amphibole masks its former pyroxene morphology in hand samples. The pyroxene displays relict basal parting and one highly altered sample contains up to 10% fine-grained interstitial quartz. Magnetite is present in minor amounts in one section. The presence of abundant altered pyroxene indicates that the rock is gabbro in composition.

Basaltic to Andesitic Dikes. On the Leadman group of islands and on Patterson Island, basaltic to andesitic dikes have strikes both parallel to and cross-cutting the penetrative schistosity of the metavolcanics. The dikes are composed of chlorite schist, weather slightly lower than the enclosing metavolcanics and have well developed chill margins up to 10 cm wide. The weathered surfaces of the dikes suggest former, well developed, bilateral symmetry with coarser-grained material located along the centre of the dikes. These dikes rarely exceed 1 m in width, weather light to dark green and are dark green on fresh surface. At several locations along the east and south coast of Patterson Island Archean mafic dikes intruded parallel to the schistosity had been segmented into boudins parallel to the schistosity. The lack of necking between the various segments suggests that this segmentation took place in a brittle fashion. The area between the dike segments is filled with milky quartz which forms rods having bearing and plunge similar to volcanic clasts in the associated pyroclastic rocks. These dikes are thought to be basalt to andesite in composition because of their dark grey-green colour and high chlorite content.

An Archean dike rock located on the northwest coast of Mortimer Island is andesitic to dacitic in composition. The dike weathers light green and has a medium green fresh surface. It contains chloritized hornblende phenocrysts 1 to 2 mm in size and is approximately 1 m wide. The phenocrysts represent about 5% of the rock by volume and the dike pinches and swells along strike, possibly as a result of boudinaging.

A dike rock of intermediate composition was noted on the west coast of Mortimer Island. These dikes weather grey-green, are medium green on fresh surface and contain tiny hornblende phenocrysts up to 1 mm across. The largest of the three dikes is 1 m in width. The dikes display a secondary schistosity and were included with the Archean rocks.

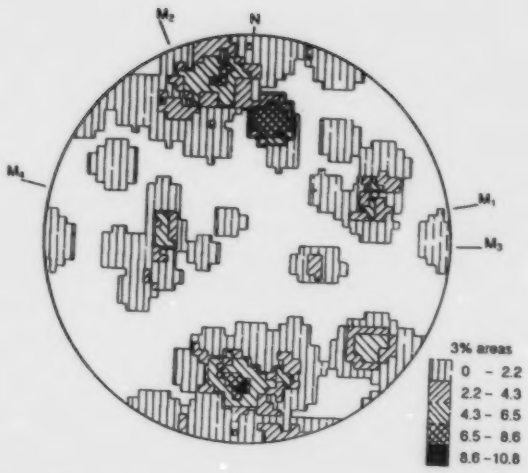

Figure 7. Contoured stereographic projection on lower hemisphere of 72 Archean mafic dike trends.

Figure 7 is a lower hemisphere stereographic projection of 72 dike trends. Several maxima are evident on the diagram. Trend M1 strikes N80°E, dips 75° south, and parallels S_1 and S_0, and thus represents sill-like intrusions. Trend M3, which strikes east and dips 70° north, and trend M4, which strikes N78°W and dips 60° south, cut S_1 and S_0 at an acute angle of 10 and 22° respectively which would make them dike-like intrusions. It is unclear as to why the M3 and M2 dikes were emplaced in this orientation. Some of these dikes may have been sheared or rotated into their present position since they predate deformation and metamorphism.

Dike trend M2 is the least definite of the four trends. It strikes N25°W and dips at 75° west and 45° east. This dike set is likely representative of the last phase of intrusion of the dikes at the beginning of significant collapse and folding of the supracrustal rocks. This dike set appears to be occupying a possible position of dilatancy in the supracrustal rocks which is normal to the direction of extension and S_1 and S_0.

Ultramafic to Mafic Intrusive Rocks. Along the south side of Francois Island serpentinized ultramafic intrusive rock is in contact with sheared mafic tuff. Along the immediate contact a 0.3 by 1 m pod of serpentine contains irregular veinlets of asbestos fibre up to 1 cm in width. Fresh and weathered surfaces are light to dark green. The rock appears to be highly variable in composition varying from peridotite to gabbro; peridotite tends to be darker shades of green and gabbro the lighter shades.

At wave level at the approximate centre of this occurrence is a vein of highly fractured apple-green soapstone. The vein is 1 m long and 4 cm in width.

Two thin sections were prepared from the gabbroic phases of the Francois Island intrusion. One section consists of a visually estimated 5% carbonate, 5% chlo-

rite and 90% actinolite and is presumed to have originally been a pyroxenite. The second section was visually estimated to contain 55% saussuritized plagioclase, 5% leucoxene, 30% actinolite, and 10% chlorite and is presumed to have been originally a gabbro.

An isolated outcrop of ultramafic serpentinite rock is present on the south coast of Mortimer Island. D. Pyke, formerly with the Ontario Geological Survey, has suggested from his experience in the Timmins area that this exposure represents an ultramafic flow, however it has been grouped with the intrusive rocks.

This ultramafic rock weathers reddish brown and is dark grey-green on fresh surface. Serpentine and talc are recognizable in some hand samples and the outcrop has a distinctive polygonal or "elephant hide" weathered surface. The outcrop has been sheared and brecciated and contains some carbonate along fractures.

In thin section the rock was observed to be composed of talc, serpentine, chlorite, and a trace of magnetite. The rock was originally composed of about 75% serpentinized olivine and has a relict sieve or mesh texture.

Lamprophyre Dikes. On the west side of the peninsula that forms the west side of Lawrence Bay, is a small lamprophyre dike approximately 60 cm wide. This dike weathers reddish brown and has a light green fresh surface. The dike is porphyritic with hornblende phenocrysts altered to chlorite up to 6 mm in size set in a fine-grained chloritic matrix. The metamorphosed nature of the dike sugggests it is Archean in age.

A second, possibly Archean, lamprophyre dike was located along the metasedimentary-metavolcanic contact on the north side of Delaute Island. This dike is 60 cm wide, weathers low, with a reddish brown to green colour, and is black on fresh surface with some red streaking. The subdued weathered profile suggests a high carbonate content. This lamprophyre is cut by an undeformed massive diabase dike assumed to be of Keweenawan age thus establishing a possible pre-Keweenawan age of lamprophyric intrusion. This dike is micaceous with small grains of biotite(?) up to 1 mm in size and has been arbitrarily included with Archean lamprophyres.

Lamprophyre dikes on the east side of Leadman Island are fragmental or clastic in appearance and contain abundant autoliths and perhaps xenoliths. The largest of these dikes strikes roughly east and occurs on the easternmost shoal. It is traceable in scattered wave-washed exposures almost onto Leadman Island where a non-clast-bearing mafic dike rock may be its on-strike continuation. On this shoal the dike is highly variable in width but approaches 25 to 30 m along its eastern wave-washed edge.

This dike rock weathers black and is black on fresh surface and locally contains very pale pink plagioclase phenocrysts up to several millimetres in size. The phenocrysts locally comprise 20% of the rock and in places are concentrated into poorly defined bands. The weathered surface is pitted (1–2 mm pits) and the dike rock is schistose and metamorphosed. The dike rock is largely a chlorite schist and is cut by numerous quartz veins. Ovoid clasts up to 8 by 6 cm and angular clasts up to 15 by 15 cm of a composition similar to that of the matrix are visible on the weathered surface. Most of these clasts are presumed to be autoliths derived from broken, previously consolidated magma that formed the dike. Some of the pitting of the weathered surface of this dike rock may represent carbonate-filled gas cavities.

An isolated outcrop in the wave-washed surf between the two major shoals on the east end of this island contains clasts up to 35 by 13 cm which are rounded to subangular in outline.

Dike rock with similar sized clasts outcrops just to the north on the east side of the large shoal closest to Leadman Island. Clasts in this exposure are angular to subrounded and up to 15 by 23 cm in size. The clasts are pitted on weathered surface and low weathering. The matrix weathers lighter green in colour and is much finer grained than the dark green somewhat coarser grained clasts. There appears to be little compositional difference between the clasts and matrix, thus the clasts are thought to be predominantly autoliths derived from previously consolidated dike rock. This exposure appears to be curvilinear in outcrop pattern and cuts the Archean quartz-feldspar porphyry intrusion which forms most of the shoal. There may be more than one age of intrusive breccia dikes in this location, but exposure is insufficient to answer this question.

Walker (1967, p.28) described similar dikes along the shore of Lake Superior between Terrace Bay and Marthon. Walker (1967, p.280) considered them to be the latest rocks in the area even though he reported that they are cut by diabase dikes on the large island in McKellar Harbour. Because of their metamorphosed nature and profuse quartz veining, the author considers them representative of an Archean period of breccia dike emplacement.

There may be a poorly defined spatial distribution of the Archean lamprophyric dikes. The dikes are most abundant along the south and southeast coast of Patterson Island and Leadman Island, and from the work of Walker (1967) they are relatively abundant in the McKellar Harbour area. This northeast trend lies parallel to and on the part of the islands closest to the Big Bay–Ashburton Bay fault zone of Hinze et al. (1966). This fault zone crosses the Lake Superior basin in a northeast direction, passing immediately south of the Slate Islands and intersecting the north coast of Lake Superior in the area of McKellar Harbour on Ashburton Bay.

Felsic to Intermediate Intrusive Rocks

Rocks of Unit 5 cover a large part of the southeast half of Patterson Island and consist of various schistose porphyritic rocks that lack any evidence of primary flow or fragmental structures. These rocks are thought to be largely representative of sill-like intrusive bodies. In general, phenocrysts in rocks of this group comprise no

more than 10 to 25% of the rock by volume. These quartz and feldspar phenocrysts are generally smaller in size and are not as abundant as phenocrysts in the feldspar-porphyry flow rocks (50–60% phenocrysts). An AFM plot (*see* Figure 16 under "Petrochemistry") shows that with one or two exceptions the intrusive rocks are tightly clustered near the "A" apex of the diagram and the flow rocks are scattered. Such scatter for the flow rocks could be anticipated since flow movement would be expected to introduce some compositional variation. While it cannot be discounted that some of these units are indeed flows lacking primary structures indicative of extrusion, they do represent mappable units which can be separated from clearly extrusive units on both chemical and field criteria. The subvolcanic intrusive interpretation is preferred here.

Schistose Porphyries. Schistose feldspar porphyry is the most abundant rock type of this group. It is gradational into schistose quartz-feldspar porphyry and schistose quartz porphyry. On the weathered surface the porphyritic rocks are grey-green, reddish brown, orange-brown, and mottled with small buff, white, red, orange, and brown feldspar phenocrysts. The phenocrysts rarely exceed 5 mm in maximum size and only rarely exceed 25% by volume of the rock. Quartz phenocrysts are ovoid in form, 1 to 3 mm in diameter and only rarely approach 5% of the rock. The host rock for the phenocrysts consists mainly of sericite and chlorite sericite schists. Rarely a dark chlorite spot of 3–5 mm diameter occurs along a broken schistosity surface suggesting the presence of a former mafic phenocryst. Those rocks that weather various shades of red, orange, and brown are usually highly carbonatized. On fresh surface the rocks are generally shades of light green or grey-green.

Mapping by members of this party and compiled data suggest that a unit of iron formation which outcrops along the east coast of Patterson island and is traceable on aeromagnetic maps approximately half way across the island appears relatively continuous and unbroken. Schistose feldspar porphyry occurs on both sides of this relatively narrow lithologic unit indicating that if the feldspar porphyries on both side of this unit are intrusive rather than flows then they were emplaced relatively passively.

Eleven thin sections were prepared from the porphyritic intrusive rocks. These rocks were visually estimated to contain on average 10 to 20% plagioclase phenocrysts of oligoclase-andesine composition. The maximum proportion of plagioclase phenocrysts observed in thin section was estimated at 50% by volume. The phenocrysts are commonly fractured, rotated and cemented with carbonate and occasionally phenocrysts form clusters of several grains. The feldspar phenocrysts are extensively replaced by carbonate and sericite and occasionally minor chlorite. The thin sections are visually estimated to contain 5–15% carbonate, 10–20% sericite and 0–5% chlorite. Polycrystalline quartz phenocrysts were present in several thin sections and comprise 10% of one section, but they are generally present in amounts not exceeding 5%. The schistosity of the rock is defined by the phyllosilicate minerals and the texture of the fine-grained polycrystalline groundmass of quartz and plagioclase which generally constitutes more than 50% of the rock is granoblastic, equigranular to slightly inequigranular. The grain boundaries of the polycrystalline matrix are curved to relatively straight.

Massive Porphyries. Massive (unfoliated) quartz-feldspar porphyry may be related to the schistose porphyries or may be a distinctly younger phase. This rock type is relatively massive and homogeneous in appearance and displays a somewhat greater concentration of quartz phenocrysts than the schistose porphyries.

An exposure of massive quartz-feldspar porphyry occurs on the large shoal immediately east of Leadman Island. This is a massive, well jointed rock which weathers light pink. On fresh surface the rock is pale pink and contains about 3–4% quartz phenocrysts up to 3 mm in diameter and 15–20% red feldspar phenocrysts which are up to 5 mm across. The phenocrysts have a seriate distribution.

In thin section, this rock was visually estimated to contain up to 10% quartz phenocrysts, 20% feldspar phenocrysts of oligoclase-andesine composition, 8–10% carbonate, 20–25% sericite, a trace of garnet and a groundmass of fine-grained quartz and plagioclase. The groundmass is granoblastic and equigranular. The ovoid quartz phenocrysts are polycrystalline and display undulatory extinction.

A similar rock occurs in a series of offshore shoals on the east side of Patterson Island where it intrudes mafic metavolcanics. These exposures weather brick red and are somewhat darker red on fresh surface. In outcrop, the rock is massive, homogeneous and contains up to 10% quartz phenocrysts, which are up to 3 mm in size. The feldspar phenocrysts make up 30% of the rock and are up to 3 mm in size. The phenocrysts are seriate in distribution. The rock contains abundant large xenolithic blocks of chlorite schist.

A thin section of this rock contains a visually estimated 5% quartz phenocrysts, 40% plagioclase phenocrysts of oligoclase-andesine composition, 5% chlorite, less than 5% carbonate, and 50% matrix of very fine-grained polycrystalline quartz and plagioclase. The plagioclase phenocrysts are fractured and range from broken and angular to euhedral crystals. The ovoid quartz phenocrysts are polycrystalline and display an undulatory extinction. The polycrystalline quartz and plagioclase matrix has a granoblastic, equigranular texture.

Along the south coast of Patterson Island are several very small occurrences of similar quartz-feldspar porphyry rocks. A thin section of one of these occurrences contains a visually estimated 10% quartz phenocrysts and 10% feldspar phenocrysts set in a polycrystalline quartz and feldspar matrix similar to that previously described.

The absence of a penetrative schistosity, and homogeneous appearance suggests that the massive quartz-feldspar porphyry may be younger than the schistose units. The presence of sericite, chlorite, carbonate and

granoblastic texture in the matrix indicates the rocks have been metamorphosed and are probably of Archean age.

Associated with the massive quartz-feldspar porphyry on the east coast of Patterson Island is a fine-grained aplitic phase containing chlorite schist inclusions with orange-red carbonate porphyroblasts up to 1 mm across. Milky quartz stringer veins and traces of disseminated pyrite are also present. This hybrid mixture of rock types appears to represent a border phase of the possibly younger quartz-feldspar porphyry intrusions.

A possible felsic dike on the north shore of Delaute Island is very fine-grained, buff to light green and cuts the mafic metavolcanics. This dike is massive, homogeneous, nonporphyritic and has a light green-grey fresh surface. The dike has carbonate-filled fractures and contains trace amounts of disseminated pyrite in grains up to 3 mm in diameter.

A local area on the south coast of Patterson Island consists of a mixed sequence of felsic intrusive and mafic volcanic rocks. The felsic intrusive rock weathers pink, green, and red, and is generally pinkish green on fresh surface. A porphyritic texture is weakly developed with small (generally less than 1 mm) feldspar phenocrysts set in a fine-grained sericitic schist matrix. The exposures along the shore show a pronounced interdigitation of the pink feldspar-porphyritic rock and fine-grained, medium green chlorite-sericite schists. One block contains up to 5% of red clasts and appears to be similar to mafic volcanic breccia on Horace Point. The sequence appears to have formed by lit-par-lit intrusion of intermediate to felsic sheets into a sequence of mafic volcanic and related slump deposits. Shear folding has undoubtedly enhanced the interdigitating appearance of the two rock types and obscured the original contact relations.

PROTEROZOIC

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Gunflint Formation

Along the west coast of Patterson Island lying above the Archean metavolcanics and below the Keweenawan volcanic rocks is a distinctive sedimentary unit believed by the author to be correlative with the Gunflint iron formation which is best exposed in the Thunder Bay area (Goodwin 1960). The difference between this unit and underlying metavolcanics is readily apparent in the field for it lacks the penetrative schistosity and deformation characteristic of the Archean rocks. The correlation with the Gunflint was suggested to the author by J.M. Franklin, (Lakehead University, personal communication, 1974) who examined the limited exposures found on the island and who is familiar with the Gunflint Formation in the Lakehead area. A.M. Goodwin, University of Toronto, briefly examined a selected suite of thin sections from the unit and confirmed this correlation.

The Gunflint unit on the islands is estimated to be a maximum of about 21 m thick but open folding and non-penetrative deformation has seriously affected the unit in most places and any estimate of thickness can be considered only an approximation. Folding of the unit consists of broad open folds and this is best displayed in a cliff face about midway along the west coast of Patterson Island. This exposure is close to the junction of the Archean and Keweenawan, and is capped by a diabase dike which lies in sharp, undulating contact displaying angular discordancy with the bedding of the Gunflint.

Chert and Argillite. The best exposure of this sequence is on the west coast of Patterson Island where the Gunflint Formation overlies the Archean and is in turn overlain by Keweenawan volcanic flows. The Gunflint at this location dips approximately 50° west and from outcrop distribution and bedding attitude appears to be in sharp angular unconformity with the Archean. The section may be 15 m thick at this location but it has been deformed, intruded by diatreme breccia and is not continuously exposed, making estimate of thickness difficult. The lowest part of the section is characterized by bright red chert, hematite, and carbonate with weathered pits up to 1 cm in diameter. The bedding is highly contorted and some bands consist of nearly pure hematite. In places the hematite is red and soft, and elsewhere steel-grey and finely crystalline. This hematite-rich portion of the section is estimated to be 3 m thick.

Above the hematite-rich base, a sequence of hematitic chert of indeterminate thickness is present. This rock is reddish brown to red on the weathered surface and contains much dusty hematite. A thin section was prepared from this layer and disclosed 0.1 to 0.6 mm granules of polycrystalline chert heavily dusted with hematite. The centres of the granules are coarser-grained than the margins. The chert matrix is fine grained next to the granules and gradually increases in grain size towards the centre of space between the granules. The hematite is commonly concentrated near the margins of the granules which enhances the outline of the granules. The granules are oblate or deformed spheroids. Some tabular, wedge-shape grains of hematite are present and some carbonate occurs interstitial to the granules. The granules appear identical to those described by Moorhouse (1960, p.26-32) from the Gunflint. The polycrystalline chert grains have straight grain boundaries with well developed triple-point junctions and are considered to have been weakly metamorphosed.

Lying above and grading into the chert containing dusty hematite is a sequence of regularly bedded, grey-white chert and dark grey to black siliceous argillite. The chert bands weather in relief with respect to the argillite and reach a maximum thickness of 38 cm (Photo 4). The thickness of the chert band is not constant along strike and the frequency and thickness of chert bands decreases up section. A thin section prepared from one of these chert bands displays polycrystalline domains of chert about 0.1 to 0.5 mm in diameter (Photo 5). The outline of the finer-grained domains are crudely ellipti-

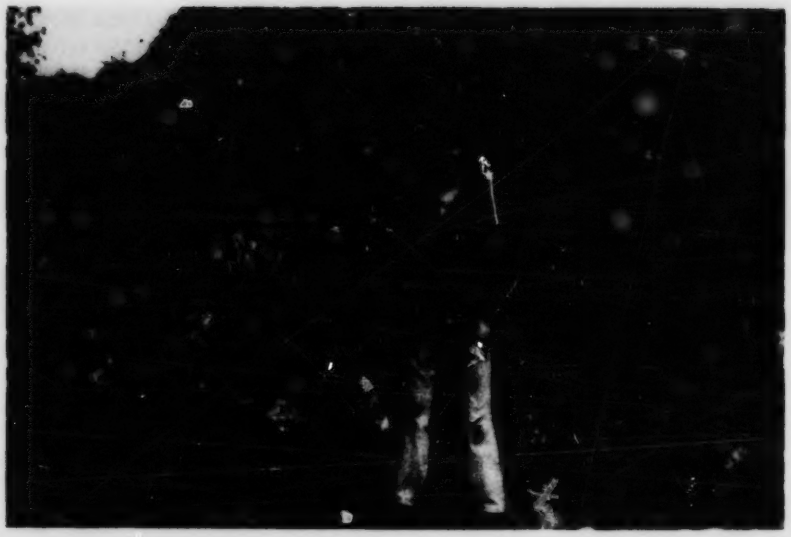

Photo 4. Interbedded chert and argillite of the upper portion of the Gunflint Formation. Location P20.

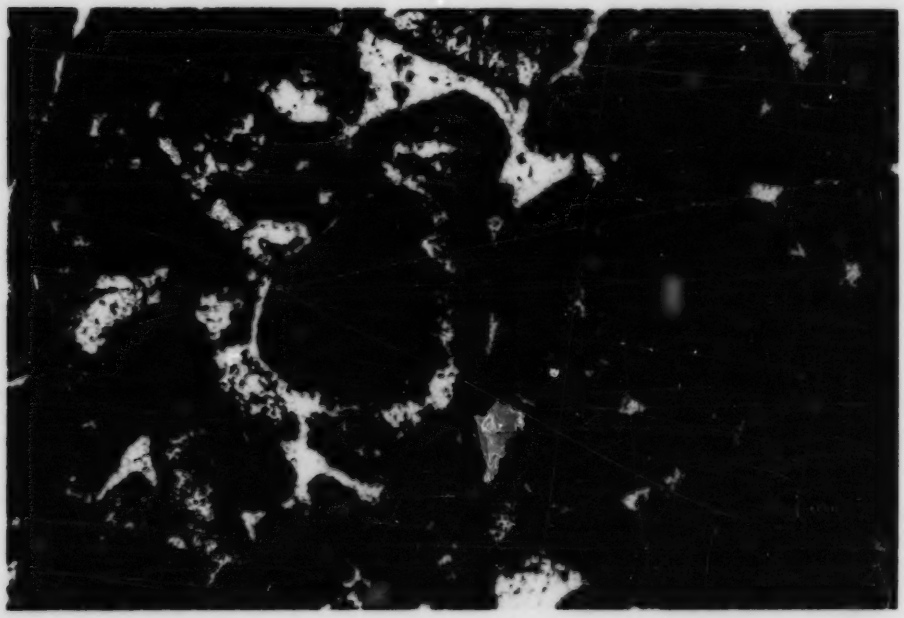

Photo 5. Photomicrograph (340 X) of granules in ferruginous chert of the Gunflint Formation. West coast of Patterson Island. Location P20.

cal and reminiscent of the granules lower down in the section. These oblate forms are thought to be granules which, due to the lack of any significant hematite content, do not prominently stand out in thin section. Some carbonate is also present.

The dark grey to black siliceous argillite is very well laminated. Individual laminae are 0.1 mm thick and the maximum grain size is 0.2 mm (quartz grain). The banding is defined by very fine-grained clastic bands, carbonaceous material, and carbonate. Fractures within the argillite are filled with carbonate and the application of hydrochloric acid to the rock gives a vigorous reaction.

Lying above the argillite and immediately below a Keweenawan volcanic flow is a small irregular patch of white carbonate. In thin section this rock consists of a visually estimated 60% calcite, 25% chert and 15% euhedral anomalous garnet. The garnet occurs as 0.05 mm grains and presumably resulted from metamorphism of the siliceous carbonate. It is uncertain as to whether this metamorphism was regional or the result

Photo 6. Pitted weathered surface of ovoid carbonate structures in Gunflint iron formation. Location P21.

of contact with the overlying flow. The overlying flow lies in sharp angular contact with the bedding within the argillite.

Iron Formation. This unit is a very distinctive facies of the Gunflint Formation and is well exposed in only one location, on the northwest shore of Patterson Island. By analogy with outcrops containing Gunflint chert and argillite, it is presumed that the iron formation is part of the lower portion of the Gunflint section.

On outcrop the rock weathers red and fresh surfaces are also red. The weathered surface is pock-marked with circular pits up to 1 cm in diameter (Photo 6) and displays bedding with individual beds up to 15 cm in maximum width. At the one exposure, the width of the unit is approximately 20 m.

In thin section the rock is visually estimated to contain 70% carbonate, 10% chert and 20% wedge-shaped, platey hematite. The hematite plates are up to 0.1 mm in length and the enclosing carbonate grains are about 0.5 mm in diameter. The hematite tends to occur along the margins of the larger carbonate grains and between the carbonate and chert. This pattern imparts a crudely circular pattern of mineral distribution. The circular pits in the weathered surface are a reflection of this mineral distribution.

Rove Formation

Along the northwest and southwest coasts of Delaute Island and at "Caribou Point" on Mortimer Island is an argillite sequence that is distinctly different from the interflow, well bedded argillites of the Archean metavolcanic sequences of Mortimer and Patterson Islands. Samples from this unit were examined in 1979 by J.M. Franklin, Geological Survey Canada, Ottawa, who expressed the opinion that this unit was Animikie Rove Formation. This is consistent with field observations and the author now considers that these limited exposures are more likely correlative with the Rove Formation located west of the islands than representing a younger less deformed period of Archean as originally indicated by the author and others (Sage et al. 1975, Goodwin 1960, Giquere 1975, McIlwaine and Wallace 1976).

The Rove argillite weathers black grey, grey-brown or grey-green, is very fine grained, relatively massive, well jointed, and only locally displays well developed bedding. Thinner, lighter weathering siltstone layers which sometimes display a well developed grain gradation are the only variation in texture or structure within this relatively homogeneous sequence. Where siltstone-argillite couplets could be identified at "Caribou Point" they were on the order of 50 to 70 cm in thickness.

On the northwest corner of Delaute Island, massive to weakly bedded argillite lies in sheared contact with mafic volcanic tuff. The argillite at this location weathers dark green, greenish black, and on fresh surface is dark green. Along the northwest coast and on the offshore shoals the argillite is massive and highly fractured. Locally a weak suggestion of bedding is present. Occasionally a small quartz grain less than 0.15 mm in diameter can be seen with the unaided eye on the freshly broken surface. The broken surface commonly displays a poorly developed conchoidal fracture.

Bedding in siltstone-argillite bands on one outcrop on the northwest coast has a northwest trend and a dip of 52° east. This trend is nearly at right angles to the trend in the well laminated Archean chert beds to the east. One siltstone-argillite bed couplet on the northwest corner has a measured thickness of 56 cm. In one outcrop, the argillite is cut by a sheared metamorphosed mafic dike about 3.5 m wide containing dark green spots of chlorite up to 3 mm.

The argillite unit is also exposed on the southwest corner of Delaute Island. The rock at this location appears identical to argillite at "Caribou Point" and on the northwest corner of the island. Bedding is again poorly displayed and individual siltstone-argillite couplets appear to be approximately 50–60 cm thick. One reliable bedding attitude indicates that the unit strikes nearly north and dips east. This trend is similar to that of the argillites on the northwest corner of the island and the bedding attitude is likewise at a very high angle to the northeast trend of laminated tuffs within the Archean mafic metavolcanics at the north end of the island which suggests that the argillite lies in angular unconformity with the Archean metavolcanic sequence. The occurrence of Rove Formation on the northeast side of the Slate Islands is the easternmost presently known exposure of this Animikie unit.

Estimated modes of thin sections of argillite samples from "Caribou Point" indicate the following composition: 0–5% carbonate, 20–25% chlorite, 20–25% quartz, 35–40% plagioclase (oligoclase-andesine), 0–10% sericite, 0–5% rock fragments, and 0–5% chert fragments. The rock fragments are possibly mafic tuff fragments. The quartz and plagioclase grains are very angular with sharp corners and edges.

KEWEENAWAN

Rocks classified as Keweenawan include the pervasive swarms of diabase dikes that cut the Archean and Animikie lithologies and lower units of the Keweenawan. The massive to amygdaloidal mafic volcanic rocks and interbedded siltstones and argillites of the Osler Group are also important components of the Keweenawan. Minor exposures of siltstone, mudstone, and arkosic sandstone on the west coast of Dupuis Island and east coast of Patterson Island are difficult to classify as to age and are arbitrarily placed in the Keweenawan. Interior to Patterson Island opposite the raised beaches in the northwest corner, angular slabs of pebbly quartzite possibly equivalent to the Sibley Group were noted but never found in place.

Osler Group

Mafic Volcanic Rocks

A limited sequence of Keweenawan, massive to amygdaloidal, mafic volcanic flows is located along the west coast of Patterson Island and on the nearby reefs. A section of approximately 120 m is exposed and 16 individual flows, varying from 1 m to 15 m in thickness, have been recognized in the 45 m upper portion of the sequence. On the basis of paleomagnetism Halls (1974a, 1979b) correlated the Keweenawan flow rocks on Patterson Island with the Osler Group on the mainland and on several islands west of the Slate Islands. This correlation appears reasonable to the author and lacking other means to establish relative age on this sequence the author accepts Halls (1974a, 1979b) interpretation.

The flows appear to get thicker towards the base, in addition, the general plan view of individual flows is lenssoid suggesting that they occupied channels or irregularities in surfaces of the underlying flows. Generally the interflow contacts are sharp and sometimes defined by thin interbeds of silt and sandstone. The upper 45 m section has been mapped in detail and all samples selected for chemical analysis and all measurements of shattercone axes and ropy lava surfaces are indicated on Figure 8 (Chart A, back pocket).

The Keweenawan mafic volcanic sequence lies with angular unconformity on the Animikie Gunflint Formation and the actual unconformity is well exposed at one location on the west of side of Patterson Island. The lower portion of the Keweenawan section has been intensely sheared and local faulting is recognizable (Photo 7). The deformation in the lower portion of the section makes the unravelling of lower stratigraphy impossible. The flows dip 25° west in the upper portion of the section and 80° west in the lower portion. Such a rapid change in dip through such a limited section suggests the possibility that deformation was contemporaneous with deposition. A brief examination of Figure 8 suggests that the shear zones represent a conjugate set, however, bedding plane shears could not be illustrated and are particularly common in the lower portions of the section. Further indication of the rapid change in intensity of deformation is the well preserved ropy lava surfaces found in the relatively undeformed and unsheared upper portion of the sequence versus the lack of such recognizable features in the lower portion. Using the arcuate pattern of the ropy surfaces as a flow direction indicator, bearings were taken on these surfaces, rotated to horizontal, and plotted on a rose diagram (*see* Figure 8). These measurements indicate a strong flow trend away from the island southwestward towards the Lake Superior basin.

Near the southern limit of this Keweenawan sequence on Patterson Island, a sharp angular unconformity between the Keweenawan rocks and Animikie is exposed (Photo 8). A steeply dipping (approximately 80°) mafic flow lies on and in sharp contact with interbedded chert and argillite of the upper portion of the Gunflint Formation. A paleosoil is not present.

This unconformity as well as the overall Keweenawan–Archean contact area which is separated by about 21 m of Animikie Gunflint Formation has been the dominant site of a diatreme intrusion. The two largest west coast diatremes occur along the extrapolated unconformity immediately south of the Keweenawan sequence and breccia diking is pervasive in the contact area north and south of these exposures of the Keweenawan. The red colour of the west coast diatreme breccia is in part due to the incorporation of Gunflint rock into the breccia.

The number of shatter cones and the degree of development appears spatially related to the breccia dikes at the base of the Keweenawan section. These cone-like fractures, commonly up to 20 cm in length but ranging from 1 to 30 cm in length have well developed lineations along their flanks and are very characteristic of shatter cone structures (Dietz 1968). The axes of these cones

Photo 7. Near-vertically dipping massive to amygdaloidal Keweenawan mafic volcanic rocks. Location P28.

Photo 8. Angular unconformity (indicated by hammer) between Keweenawan (Osler Group) and Gunflint. Interbedded argillite-chert of the Gunflint Formation is on the left and the bottom of the overlying mafic flow of the Osler Group is on the right. Note sharp clean contact and how base of flow sharply truncates bedding in Gunflint. Location P20.

were measured and plotted on the lower hemisphere steronet projection and contoured (*see* Figure 8). These measurements indicate that the predominant direction of cone axis alignment was horizontal to 10° below the horizontal. A plot of the cone apexes on a rose diagram indicates a strong apex direction towards the interior of Patterson island (Figure 8). There are occasional cone apices pointed away from the islands as indicated on Figure 8.

The contoured steronet (Figure 8) also demonstrates that the axes define a point or circle and not a great circle. This suggests that the shock event creating this feature post-dated the tipping of the flows into their present attitude. Since these measurements were largely made in the upper 45 m of the section the case for their development after tipping could be questioned. However, a change in dip of approximately 55° occurs in this section which, with the "bulls-eye" contouring, supports the conclusion of development being post-tipping. This shock event presumably is related to the diatreme emplacement, for the intensity and degree of development of the cone structures increases towards diatreme breccia dikes.

The Keweenawan volcanic rocks have also been intruded by diabase sill(s); the best example is indicated on Figure 8 in the vicinity of sample 52. This sill is approximately 18 m thick, and has been cut by an intrusive breccia along its upper surface. This dike displays very well developed columnar jointing and has been faulted after emplacement of the intrusive breccia. Other diabase dikes are present in the section but are much smaller in size. The larger of these dikes may have served as feeders for flows higher up in the section.

The volcanic flows weather black, brownish black, grey-black, reddish brown or greenish black. On fresh surfaces the volcanic rocks are black or greenish grey-black with brownish tints. The rock is generally fine grained although some flow centres are medium grained. The thicker flows have amygdaloidal tops grading downwards into more massive cores while the thinner flows are vesicular throughout. The vesicles range up to 2 cm in diameter and are filled with calcite and/or agate. The agate is white, pale blue, pale pink, and well banded, however the larger agates generally have coarsely crystalline white quartz in their cores. The carbonate filling the vesicles is generally white. At one or two exposures pipe amygdules were noted in the base of a flow unit. These are approximately 1 cm in diameter, 4 to 5 cm long and were of no value in indicating flow direction.

One large piece of float along the beach displays a well-developed flow banding defined by the relative variation in the concentration of amygdules. The amygdules are filled with white calcite. The source of this boulder could not be located.

On an offshore reef towards the southern limit of the exposed Keweenawan section some spheroid to elliptical structures were noted in the base of one flow unit. These structures are up to 10 cm in maximum diameter and consist of amygdaloidal basalt of a composition similar to either the underlying or overlying flow. These structures could be (1) accretionary lava balls, (2) partially assimilated fragments from the surface of the underlying flow, or (3) partially assimilated volcanic bombs. Of these, (2) and (3) appear to be the most likely and the author prefers (2) since the size and degree of amygdule development is similar to the underlying flow.

In several areas, irregular veinlets of white and orange calcite are present. The carbonate is very coarse grained and locally contains chalcocite with minor specularite in concentrations visually estimated to approach 3%. The orange carbonate fills the vein centres and may be the later of the two carbonates.

On the outcrop containing the ovoid spheroids, carbonate veining strikes N50°W and varies from 4 to 20 cm in width. These veins are more like carbonatized breccia zones and presumably they represent carbonate cemented shear zones.

In float along the beach several large specimens of vuggy quartz and calcite were collected. These samples indicated a vein width of 20–25 cm with vugs containing scalenohedrons of calcite up to 5 cm in length on quartz crystals with a weak smoky or amethyst tint. The flanks of the samples show strongly developed slickensides. The sharply bounded nature of the samples suggests that they came from a fracture or fault filling. The source for the samples was not located.

Thin sections were prepared from five samples collected from massive flow centers for chemical analysis. The mode is highly variable and the rocks are highly altered. In thin section the rocks are seen to consist of roughly 35% pyroxene (augite) altered to a brown possibly ferruginous mineral, 50% plagioclase of labradorite composition, 15% devitrified glass, and 0.5% magnetite. These represent the original mineralogy. Leucoxene, pumpellyite, chlorite and carbonate were identified as alteration products.

Chemical analyses (Appendix A) show the exceptionally high degree of alteration of these Keweenawan rocks. Twelve analyses of mafic flow rocks of the Osler Group, west of the Slate Islands, from McIlwaine and Wallace (1976) have an average $CO_2 + H_2O$ content of 2.58% compared with 8.29% for the five Slate Islands specimens. This is more than a three-fold increase in volatile content. Tentatively this high degree of alteration is correlated by the author with the addition of volatile fluids to the sequence following diatreme emplacement and associated brecciation. The present mineralogy is consistent with an upper zeolite to lower greenschist facies of regional metamorphism.

An AFM plot of the chemical analyses (*see* "Petrochemistry") indicates that the flows are tholeiitic. A comparison of the chemical compositions of the flows and the diabase dikes confirms that the dikes may have served as feeders for the flows.

Near the south end of the exposed Keweenawan section, which from the general outcrop distribution is apparently lying immediately above the Archean, is one

outcrop of brecciated mafic volcanics. This outcrop has a weak but visible clastic appearance on weathered surface. The diffuse clasts are elongate, 53 by 13 cm, have a greenish tint, and are set in a greenish-black matrix. The rock is very fine-grained aphanitic. This isolated exposure is tentatively classed as a mafic flow breccia.

Interflow Sedimentary Rocks

Interbedded with the mafic flow rocks of the Keweenawan sequence on the west shore of Patterson Island are thin beds of red-brown sandstone and/or siltstone with maximum thickness of approximately 1 m. These sedimentary rocks are lensoid in plan view and represent an accumulation of sand and silt on the irregular surfaces of the flows. Siltstone beds in mixed sand and siltstone units are on the order of 2.5 cm thick. The finer-grained silty layers are a much darker reddish brown than the sandstone beds. The sand and siltstone beds are gradational into each other over widths of several millimetres and from a distance appear rather sharp. Where the interflow sediments have been subjected to the shock event of diatreme emplacement, the siltstone layers display the best development of shatter cones. One crudely formed shatter cone in a sandstone unit is approximately 0.3 m in length.

In thin section the sandstone layers are visually estimated to consist of 5% microcline perthite, 5–10% chert, 15–20% plagioclase (oligoclase-andesine), 50% quartz, and 20–30% carbonate cement. The rock is a lithic arkose (classification of Folk 1968, p.128), if chert is considered to be a lithic component. Several grains of altered mafic volcanic material are also present and limonite staining was noted. The grains average between 0.1 and 0.2 mm in diameter, are subrounded to subangular and are set in a carbonate cement. Some of the clastic plagioclase is weakly saussuritized.

Along the east shore and near to the northeast corner of Patterson Island is an outcrop of mudstone breccia. This breccia is not like the diatreme breccias on the islands for it is buff to very light green in contrast to the normal red colour of the diatremes. In addition, this breccia breaks into irregular horizontal slabs which is not characteristic of the diatreme breccias. This unit appears to lie in angular unconformity upon Archean feldspar porphyry and was traced along the coast for 7.2 m. Individual slabs have a maximum thickness of 4–7 cm and no evidence of bedding was observed. The breccia clasts are angular, up to 5–6 cm in length and consist of Archean rock types including a black argillite. The true age of this rock is unknown and its classification as Keweenawan can be considered at best only tentative for it may also be Animikie.

In thin sections the rock was observed to consist predominantly of highly saussuritized plagioclase grains that average 0.05 mm in diameter, and a scattering of quartz grains of similar size. The grains are angular to subangular.

Another problematical outcrop occurs midway up the west coast of Dupuis Island. At this one location and at one or two sites very close by, a highly brecciated pebbly arkosic sandstone is present. The largest block within the sandstone breccia is 70 by 60 cm. The sandstone displays weakly developed grain gradations with rounded to subrounded pebbles up to 7 mm in the base of some beds. The rock weathers reddish brown to dark red and the bedding is defined in part by varying colour hues with some bedding approaching grey-white in colour. The individual beds are on the order of 4 to 10 cm thick and on the weathered surface the feldspar content of the sandstone is noticeable due to the grey-white weathering of the clastic feldspar grains. The cement is a white carbonate which upon rotation in the sunlight exhibits cleavage surfaces on the order of 2.5 cm across. One hand sample shows a disruption of the normal layer-cake bedding and this is thought to be the result of soft sediment slump.

In thin section the detrital grains range from 0.1 to 0.6 mm in size and are angular to subangular in outline. The carbonate cement is very coarsely crystalline. The visually estimated mode is 20% plagioclase (andesine), 5% microcline, 35% quartz, 5% chert, and 40% carbonate. The rock was classed as a lithic arkosic sandstone.

The relative age of this exposure(s) is uncertain and it is not unlike some exposures of Sibley sedimentary rocks briefly examined by the author in the Thunder Bay area. The detrital grains are also similar in appearance to interflow sandstone and siltstone units within the Keweenawan section on the west shore of Patterson Island.

Diabase Dikes

Diabase Dikes. One of the notable characteristics of the Slate Islands and in particular Patterson Island is the pervasive injection of mafic dike rocks. The influence of the dikes on the island geology is readily discernible even before landing on the main island of Patterson. The walls, cliffs, grottos, and general ruggedness of the coastline are largely the result of the influence of these dikes. The dike system is so intensively developed that study of the dikes themselves would be a significant project. The present shape and form of the islands can in part be attributed to the presence of the dikes. The dikes have formed a network which has helped shield the more easily eroded schistose Archean rocks from Pleistocene glaciation and the present and past wave action of Lake Superior. The dikes occur in all sizes and are tabular to lensoid bodies in plan view. They do not have the great strike length of similar dikes on the mainland and, rather than having straight vertical walls as characteristic of mainland dikes, they commonly have irregular and bulbous contacts and may occur as gently dipping to nearly flat-lying sheets. The dikes in several instances switch from a general vertical attitude to a gently dipping or nearly horizontal form. In addition, the direction of flow, as determined on the ropy lava surfaces of the Keweenawan extrusives, indicates that the Keweenawan volcanics flowed away from the island. This last observation in conjunction with similar degrees of metamorphism, composition and the fact that a diabase dike

cuts the lower portion of the Keweenawan flow sequence has prompted the author to interpret the dikes as probable feeders for the flows and therefore the island was a centre for Keweenawan volcanism.

Since the intruded Archean rocks have a penetrative, largely vertical schistosity, it would be anticipated that the dikes would reach much higher crustal levels before becoming bulbous than they would with a horizontally anisotropic stratigraphy. Consequently it is suggested that the present level of erosion is not deep. The bulbous and sometimes lateral movement of the diabase magma suggests a lithostatic pressure less than hydrostatic pressure. Erosion has therefore not penetrated deeply below the former Keweenawan stratigraphy and has for the most part removed only the volcanic edifice above the dike swarm.

The thinner dikes are very fine grained and basaltic. The fine- to medium-grained dikes have well-developed diabasic texture along the margins, and the coarser-grained interiors of the sills and dikes are more typically equigranular in texture.

The age relations between the various diabase dikes cannot be established on field criteria alone. Cross-cutting relations between dike types were not observed and the degree of metamorphism is relative, being dependent on dike size and proximity to contact with wall rocks rather than dike age. The mafic rocks were emplaced into a Archean sequence of high volatile content (water and carbon dioxide) and almost invariably the smaller dikes are nearly completely altered as are some of the margins of the larger ones (see Appendix A for chemical analyses). The metamorphism of the dikes is presumed to be an autometamorphic process with the water and carbon dioxide derived at the time of intrusion from the enclosing Archean schists. Most dikes display well developed chilled contacts which generally vary from 1 cm to 10 cm in width. K. Treacher (Ontario Geological Survey, personal communication, 1980) reported to the author that some of the larger diabase dikes upon detailed inspection are actually a series of closely spaced dikes separated by narrow septums of wall rock.

During the course of mapping, dike attitudes were measured where possible. A contoured stereonet (Figure 9) shows a considerable spread in dike attitudes with a strong maxima (D_3) defined by a plane striking approximately 15° south of east and dipping steeply south. Two other maxima are indicated which define a northeast-striking plane dipping steeply south (D_2) and a second plane dipping steeply north (D_1). These planes represent a change in strike of about 12° and probably represent the same dike set; the strikes were averaged giving an approximate N60°E trend and vertical dip. The angle between D_3 and the average of D_2 and D_1 is approximately 50° suggesting that the dikes may be a conjugate set. The intersection of these two dike sets strikes approximately S60°W and plunges 76° southwest.

The mappable dikes include (1) diabase, (2) red alkalic diabase, (3) feldspar-porphyritic diabase and (4) pyroxene-porphyritic diabase. The diabase dikes weather black, brownish black, brown, and greenish black. On fresh surface the dikes are black, greenish black, or brownish black. The rocks are massive, very fine grained to medium grained, and equigranular. In thin section the diabase consists of roughly equal amounts of labradorite feldspar (An_{43-66}) and augite pyroxene. Minor amounts of magnetite and varying quantities of chlorite, quartz, iddingsite(?), sericite, granophyre, hypersthene, and olivine are present. The dikes are highly variable in degree of alteration and range from very fresh in appearance to extensively clouded with saussurite, chlorite and reddish-brown alterations of the pyroxenes and plagioclase. The more sodic plagioclase (andesine) is typical of the more altered dikes.

A number of the dikes on the west and south shores of Patterson Island contain olivine in quantities approaching 30%. These dikes were classed as olivine diabase where olivine exceeds 10%. The olivine diabase dikes were not coded separately on the accompanying map. The dikes range from very fresh in appearance to those in which all the olivine had been altered to a reddish-brown material tentatively identified as iddingsite. Minor quantities of hypersthene are commonly present. The diabase, olivine diabase, hypersthene olivine diabase, and hypersthene diabase appear gradational into each other.

Porphyritic Diabase. On a shoal on the northeast shore of Patterson Island a diabase dike contains tiny green plagioclase phenocrysts up to 8 mm in length. Some of the plagioclase crystals form clusters and could be considered as glomeroporphyritic. The dike is irregular in width, averaging less than 1 m, and light brown on weathered surface. On fresh surface it is green. In thin section the rock is very fine grained, highly altered to

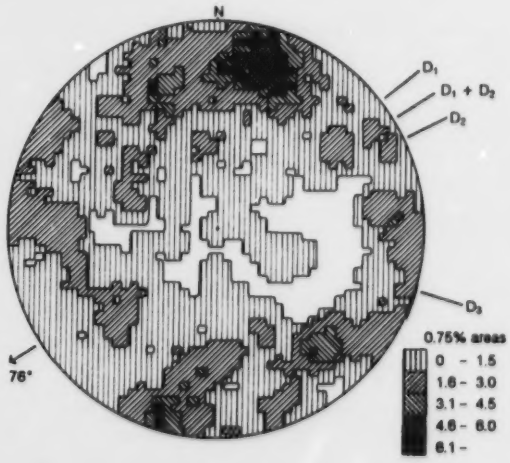

Figure 9. Contoured stereoplot on lower hemisphere of Keweenawan diabase dikes from 200 data points; D_1, D_2, and D_3 are main trends of dikes; $D_1 + D_2$ average of D_1 and D_2; line of intersection of $D_1 + D_2$ and D_3 plunges 76°SW.

saussurite and contains 5–10% finely disseminated magnetite and less than 1% tiny plagioclase phenocrysts.

Dikes containing pyroxene phenocrysts or their altered equivalent are located about midway up the east coast of Patterson Island and along the north side of Patterson Island from "Amygdaloid Island" in the west to a point on the coast northeast of McGreevy Harbour. The dike rock is characterized by the presence of two types of phenocrysts: dark greenish black and light apple green. Both were interpreted as pyroxene in the field and the light green phenocryst was confirmed as pyroxene by an X-ray diffraction pattern (Geoscience Laboratories, Ontario Geological Survey). The dark green crystals gave dolomite and calcite patterns. In thin section the light green pyroxene is augite and the dark green phenocryst is so extensively altered as to preclude positive identification. Some relict cleavage patterns suggest a former pyroxene of unknown composition. Both phenocryst types compose less than 1% of the rock on the outcrop surface with the light apple green phenocrysts being much less common than the dark green ones. These phenocrysts reach a maximum size of 1 cm and are seriate in size distribution. Locally the dike has a surface with 3–4 mm pits from which carbonate has been weathered.

In thin section the pyroxene-porphyritic rock is dominantly composed of very fine-grained plagioclase (labradorite An_{50-67}) and calcic pyroxene. The augite phenocrysts are similar in composition to the groundmass pyroxene. The rock is generally extensively altered, and chlorite, serpentine, and sericite are common constituents. Trace amounts of magnetite are present and some of the carbonate, chlorite, and sericite occurs in small oblate clots. Presumably this feature has given rise to the local presence of tiny pits on the weathered surface of the dike. A reddish-brown alteration, presumably a limonitic stain was noted in one thin section. Analyses of samples 64 and 65 (Appendix A) indicate that these dikes have a bulk chemistry generally similar to other diabase rocks on the island.

Red Alkalic Diabase. A distinctive fine-grained dike rock, originally mapped as mafic syenite, is diabase with brick red feldspars. The dikes are generally very irregular in plan view and defy determination of attitude. These dikes were noted on Spar Island, Cape Island, and on the northeast and northwest shores of Patterson Island. The red diabase dike striking northwest from the northwest corner of Patterson Island is the only dike with a clearly established trend. The dikes on Cape Island and several of those on the northeast shore of Patterson Island are shallow-dipping bodies that overlie Archean rocks.

On weathered surface the rock is mottled red and black and on fresh surface the same colours are evident. In thin section the rock displays a normal diabasic texture and is composed of nearly equal amounts of labradorite plagioclase and augite. Minor amounts of magnetite, hypersthene, and apatite are also present. The dikes are moderately saussuritized.

Major and trace element analyses (samples 66 and 67, Tables A–2, A–3, Appendix A) show that the dikes are alkalic in nature. The red diabase has a higher potassium and phosphorus content than the normal diabase. In addition the barium and strontium content is unusually high. These latter two elements are likely held in the apatite.

Intrusive Breccia. Along the west shore of Patterson Island a west-dipping sill-like body of diabase forms a prominent hill within the Keweenawan section. Columnar jointing is well developed and along the upper surface of the sill is a zone of massive breccia approximately 4 m thick. The breccia lies in sharp contact with the underlying sill (Photo 9). The true thickness of the breccia is difficult to measure due to the oblique erosion surface.

The breccia contains rounded fragments of fine-grained diabase and chert in a matrix of very fine-grained, chilled, largely nonvesicular diabase. The fine-grained diabase fragments were likely derived from the chilled margin of the lower sill and the chert from the Gunflint Formation which in this locality would lie some distance below the sill. The rounded clasts of chert are up to 48 by 26 cm in size and coated with very fine-grained chilled diabase. The diabase clasts are much smaller than the chert clasts. The underlying sill is 18 m thick and is locally amygdaloidal at both upper and lower contacts. The lower contact is sheared and lies on amygdaloidal mafic volcanic rocks of Keweenawan age. The amygdules are likely the result of local accumulations of steam generated at the time of emplacement of the magma into the water saturated Keweenawan volcanics and interbedded sediments.

In thin section polycrystalline, recrystallized, and non-recrystallized grains of chert have developed lobate or cuspate margins and have undergone assimilation by the diabase. Some of the partially assimilated quartz fragments display a weak concentration of mafic minerals around their peripheries and one grain displays well developed fine-grained radiating tufts of a prismatic mineral, possibly amphibole. Those chert grains which have been recrystallized generally lack undulatory extinction and none of the grains, recrystallized or non-recrystallized, were noted to contain distinct deformation lamellae.

Diabase fragments in the chilled diabase matrix contain plagioclase crystals with well developed cleavages and very weakly developed cuspate or embayed margins where they lie along the edge of the fragment in contact with the enclosing diabase matrix. The finer-grained diabase of the matrix locally penetrates into the margins of the fragments as lobate intrusions. The lack of well-developed cuspate to embayed fragment boundaries and the generally straight edges are taken to indicate that the fine-grained diabase fragments underwent only mild resorption. These observations are consistent with the fact that the intruding diabase would be expected to be more reactive with the quartz than with diabase of the same composition as the intruding magma.

Photo 9. Intrusive breccia on upper surface of diabase sill. Clasts consisting predominantly of Gunflint chert and fine-grained chilled diabase are set in a matrix of diabase. The diabase sill cuts Keweenawan amygdaloidal mafic volcanic rocks. Note the sharp contact between the breccia and diabase sill. Location P23.

The very fine-grained diabase matrix consists of plagioclase (An_{43}) and an ill-defined, reddish-brown alteration product after pyroxene. Minor amounts of interstitial granophyre are also present.

The breccia on top of the sill is unique among the breccias on the island, because it has a clearly recognizable igneous matrix. It is thought that this breccia is an intrusive breccia at the leading edge of a diabase sill emplaced along the upper contact of an older diabase sill. At a deeper level the breccia would likely disappear and diabase become dominant. The north end of this diabase sill and accompanying intrusive breccia has been offset approximately 10 m by a small fault. This minor fault is thus the latest recognizable tectonic event on the islands with the exception of the diatreme emplacement event.

The author would interpret this breccia as possibly an older diatreme event, which closely preceded intrusion of the diabase that engulfed the brecciated fragments. The rounding of the Gunflint and diabase clasts is likely the result of milling of the fragments by gas discharge at the time of breccia formation. Halls (1979) interpreted this breccia as a conglomerate incorporated into a flow top. The author does not share this interpretation for the following reasons:

1. Both upper and lower contacts display a similar degree of amygdaloidal development implying bilateral symmetry more characteristic of a sill than a flow. The intense vesicularity characteristic of the other Keweenawan flows is not developed in this unit which has a structure more typical of the numerous diabase dikes found on the island.
2. The diabasic matrix of the breccia is not nearly as amygdaloidal as the flow tops of the associated flows. If this unit is a flow top, then a similar degree of vesicular development could be anticipated.
3. Both diabase and Gunflint clasts display evidence of reaction and/or assimilation with enclosing diabase. The author interprets the diabase clasts as being derived from the chilled margin of the underlying sill; thus they were solid at the time of incorporation into diabase matrix. According to Halls' (1979) interpretation, they would probably be autoliths derived from chilled portions of the proposed flow.
4. Keweenawan interflow sedimentary rocks in the Keweenawan section in all other cases consist of red siltstone and sandstone suggesting a much lower energy environment than required to produce such coarse conglomerates as implied by the boulder-size chert clasts.
5. The interflow sedimentary rocks consist of rounded to subrounded grains of quartz, microcline, and plagioclase with only minor chert. The sediment provenance would appear more likely to be granodioritic which contrasts markedly with the exclusively Gunflint source required for a conglomeratic origin for the clasts.
6. The proposed conglomerate would be most unusual in that it consists solely of Gunflint clasts.
7. Conglomerates, composed dominantly of Gunflint clasts, are reported by Franklin and Kustra (1970, p.64) and Goodwin (1960, p.17, 18) at Pass Lake on the Sibley Penninsula, approximately 100 km west of the Slate Islands but there is no geological data

indicating such conglomerates exist or ever existed in proximity to the Slate Islands.

8. The conglomerate at Pass Lake lies at the base of the Sibley Formation which lies unconformably on Rove Formation. On the Slate Islands Keweenawan mafic flows lie directly on argillite and chert of the upper part of the Gunflint Formation. No conglomerate has been observed in outcrop at this angular unconformity.
9. The present position of the breccia lies within the Keweenawan rocks and thus is stratigraphically above any proposed Sibley–Rove unconformity as well as the Gunflint Formation from which the chert clasts were derived. While feasible, or remotely possible, the only way this could be a conglomerate incorporated in a flow top is for it to have flowed to the present site bringing the clasts from an unknown source area which, on the basis of present geological information, is no longer exposed or has been removed by erosion.

The author originally classified this breccia along with the other diatreme breccia, found on the islands as Keweenawan (Sage et al. 1975). Subsequently the author has obtained a potassium-argon isotopic age on a carbonatite-lamprophyre dike on the southeast coast of Patterson Island which modifies this original interpretation. This dike has an isotopic age of approximately 300 Ma and is cut by diatreme breccia dikes (D. Watkinson, Carleton University, personal communication). The author prefers to retain a Keweenawan age for the breccia with diabasic matrix and suggests that it may be correlative with the diabase events found both on the islands and the mainland (Sage 1978a,b). This breccia appears related to diabase emplacement and thus is not analogous in genesis to those diatremes found on the mainland (Sage 1978).

PALEOZOIC

PENNSYLVANIAN

Lamprophyre

Several distinctive outcrops of blue-grey lamprophyre are located along the southeast coast of Patterson Island. These were tentatively classed in the field as gabbroic (Sage et al. 1975) on the basis of hard, tiny, white mineral grains thought to be plagioclase. Subsequent petrographic examination indicated that the white grains are polycrystalline aggregates of garnet and the rock was reclassified as lamprophyre with carbonatitic affinities. On weathered surfaces the rock is blue-grey to grey-green and the local presence of dark-green olivine phenocrysts gives the outcrop a distinctive spotted appearance (Photo 10). These olivine phenocrysts reach a maximum size of 1 cm, make up about 1% of the rock and are seriate in size distribution. The rock displays a prominent joint pattern and on broken surfaces is black or dark greenish black.

A reef composed of this rock type occurs along the southeast coast of Patterson Island and would indicate that the dike is 30 m or more in width. The dike(s) are exposed in a series of disconnected segments striking northeast across the southeast corner of Patterson Island, slightly oblique to the Archean stratigraphy and parallel to the inferred Big Bay–Ashburton Bay fault zone of Hinze et al. (1966).

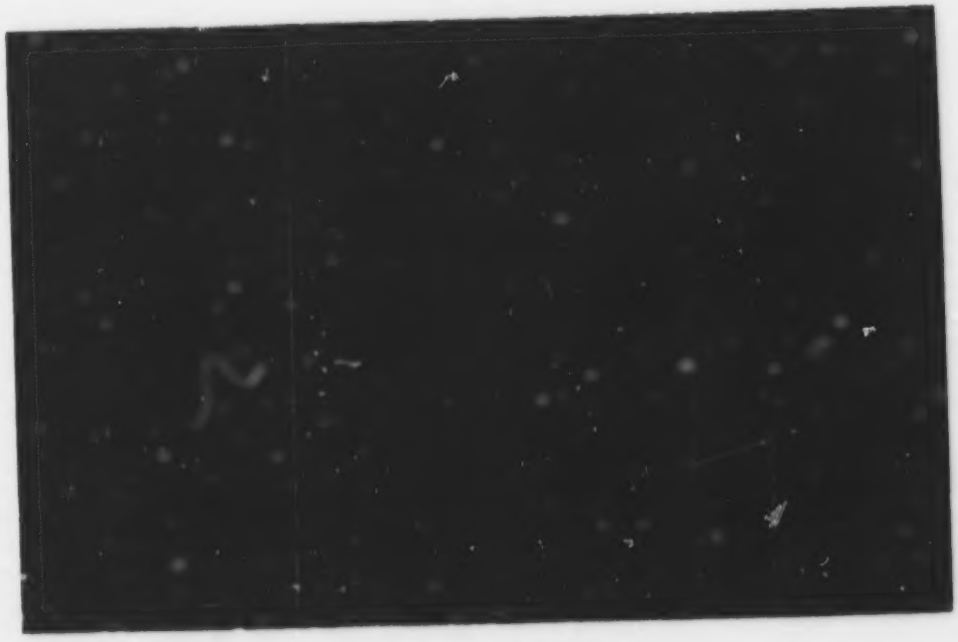

Photo 10. Location P26. Olivine phenocrysts in lamprophyric intrusive rock.

On the most northeasterly reef composed completely of lamprophyre, the dike appears to be brecciated in several places. This apparent primary brecciation may be the result of weak alteration along joint surfaces and therefore actually may be a pseudobrecciation, and the apparent clasts skialiths. Alteration along joints giving a brecciated appearance was noticeable on a second reef outcrop along the extreme southeast corner of the island lying northwest of Cove Island.

A later, very distinctive brecciation is also particularly noticeable on the reef. This brecciation is defined by darker blue-grey to blue-green clasts set in a fine-grained, rusty brown matrix. This matrix is soft and appears to be similar in composition and mineralogy to the clasts with the exception of visually identifiable olivines. These clasts range up to 15 by 8 cm in size, are angular in outline, and are interpreted to be the result of autobrecciation related to the final emplacement of the dike and release of volatiles.

Along the north contact of the most southwesterly of this series of lamprophyre intrusions, and located on Patterson Island, a contact between the dike and Archean rocks has a well-developed contact metamorphic hornfels. This hornfels development is 5 cm wide and the rock breaks in an irregular blocky fashion. This feature was not examined in thin section.

Several thin sections were prepared from samples of the dike rock. The mineralogy between sections is highly variable and no average mode can be given. The rock consists of olivine, garnet, phlogopite, magnetite, chlorite, serpentine, perovskite, calcite, apatite and talc.

The olivine is extensively altered to chlorite and talc and/or serpentine. Where fresh olivine was identified it was a dark yellow-brown and is presumed to be fayalitic in composition. The perovskite occurs in sharply euhedral grains of a maximum 0.1 mm diameter with square to octahedral outlines that display a very weak anisotropism. The garnet is dark brown in thin section and forms aggregates of grains which are individually up to 0.1 mm in diameter and lack any euhedral outline. The magnetite occurs in distinct crystalline grains of approximately 0.1 mm diameter. On the reef of lamprophyre northwest of Cove Island a fracture in the lamprophyre contains a hard greenish mineral with subordinate greenish mica. An X-ray diffraction pattern of the hard greenish mineral indicated garnet (W. Hicks, Geoscience Laboratories, Ontario Geological Survey).

The mineralogy of the dike is characteristic or similar to numerous samples examined by the author from several carbonatite intrusions. This dike is considered to be part of the alkalic magmatic events associated with the northern extension of the Big Bay–Ashburton Bay fault of Hinze et al. (1966).

Potassium-argon isotopic ages were obtained on phlogopite and antigorite from this dike by D. Watkinson (Carleton University, personal communication, 1977). The phlogopite returned an age of 282 ± 11 Ma and antigorite 310 ± 18 Ma. The rock is thus Pennsylvanian in age and the youngest alkalic rock presently known from the alkalic rock–carbonatite province north of Lake Superior. This dike is cut by diatreme breccia dikes indicating a post–Pennsylvanian age for the diatremes.

POST–PENNSYLVANIAN

Diatreme Breccia Dikes

Breccia dikes, forming an anastomosing network, cut all rock types on the islands and are exposed along the western, southern and eastern coasts of Patterson Island, on shoals off the coast of Patterson and Dupuis Islands, and on Spar Island (Figure 10). Along the east coast of Patterson Island, intrusive breccias were recognized beneath the waters of Lake Superior, where they are best observed in the early spring before the algal growth has covered the lake bottom. On the southeast coast of Patterson Island these dikes cut and enclose blocks of lamprophyre with carbonatitic affinity that has been dated isotopically by potassium-argon techniques at 300 Ma. The diatreme event is thus equal to or younger than 300 Ma. East of Dupuis Island, the breccia dikes are present on submerged shoals. The relative abundance of the breccias along the coast of Patterson Island is in part attributable to the excellent exposure there. Dikes are present within the interior of Patterson Island, but they are either not as well exposed or, perhaps, not as well developed. In addition, along the west and south coasts of Patterson Island, the Keweenawan–Archean contact may have been a strong influence on the location of diatreme intrusion. The development of diatremes has been traced onto the mainland to the vicinity of the east flank at the Port Coldwell alkalic complex, where the author re-examined in 1975 a unit mapped as Animikie conglomerate on McKellar Creek by Walker (1967), and reinterpreted it as a northeast-striking diatreme breccia dike. This diatreme is poorly exposed and relatively small compared to the Slate Island intrusions. Shatter cone structures were not observed in outcrop at the McKellar Creek diatreme but deformation lamellae in quartz were observed in thin sections prepared from samples of this dike. This northeast-striking breccia dike is on strike with a northeasterly extension of the Big Bay–Ashburton Bay fault of Hinze et al. (1966) and in all probability is related to the Slate Islands by structure, even though it appears to be an older event (Sage 1978). Northeast of the McKellar Creek structure is the Deadhorse Creek diatreme which also lies on trend of the Big Bay–Ashburton Bay fault zone (Sage 1978, Mitchell and Platt 1977, p.11).

The Slate Island breccias consist of sharply angular to sub-rounded fragments, as much as 4 m in maximum dimension, derived locally from the Precambrian rocks and set in a matrix of comminuted rock debris of similar derivation. The breccias are indurated but are easily eroded and can be sampled with little effort, as they readily fall apart upon being hammered. The breccias are chaotic and generally lack any evidence for fragment sorting and thus are homogeneous in appearance across any given exposure. Dike widths locally approaching 30 m were observed. Except for one occurrence, the brec-

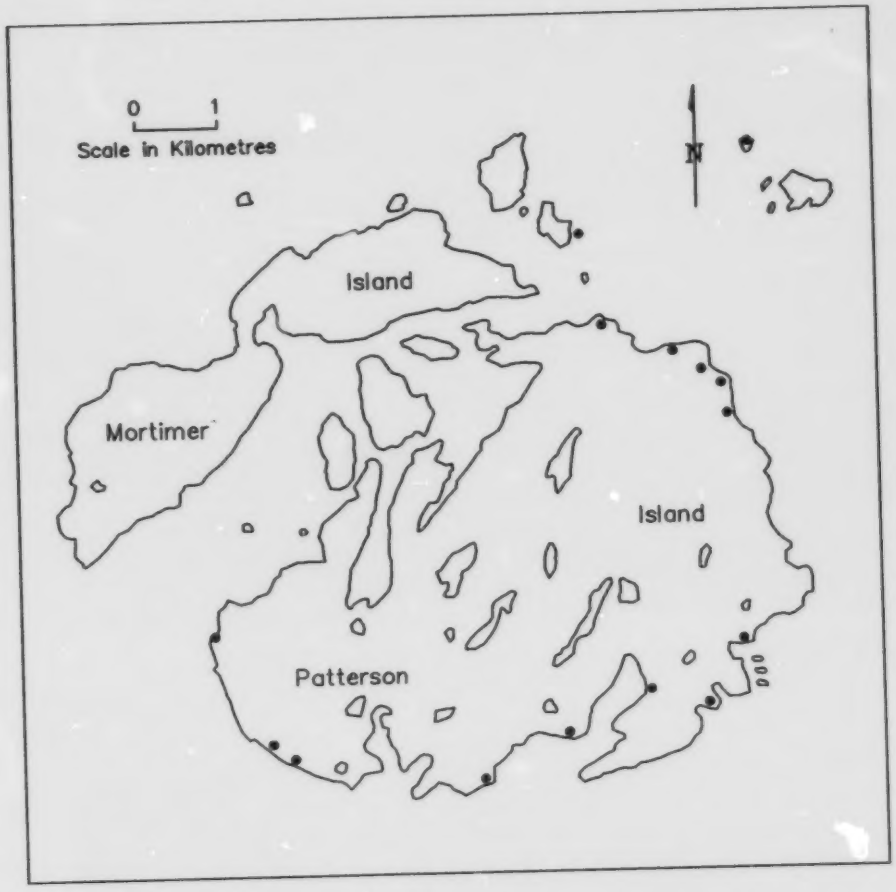

Figure 10. Some areas of more prominent diatreme breccia development on the Slate Islands.

cias are undeformed and lack any evidence of having undergone post-emplacement tectonism.

In outcrop areas where dikes are especially abundant, large bedrock blocks between and within the dikes have undergone little or no rotation. Unrotated or slightly rotated blocks of bedrock up to 15 m on a side were observed to be enclosed by dikes of breccia. Because of the lack of any significant rotation of the large blocks, it is possible to trace lithologic units and structural trends through areas of extensive breccia-dike intrusion.

Source of Breccia Dike Colour. The diatreme breccias are brick-red, grey, and greenish grey. The grey and greenish grey colour is more typical of the smaller dikes and red of the larger dikes. The west coast breccia dikes are generally deep red and derive their colouration in part from the presence of comminuted hematite-bearing Gunflint Formation and in part from hydrothermal activity related to their emplacement. The east coast breccias are a much lighter shade of red. This lighter colour of east coast breccias is from a pulverulent, fine-grained hematite likely exclusively related to hydrothermal activity at the time of emplacement. Clasts of Gunflint Formation are absent in the east coast breccias and common in those along the west coast.

Fragment Alteration. Little visual evidence was seen in the vast majority of breccias for any significant alteration of the fragments in the hematite-impregnated matrix, suggesting that the fluids accompanying diatreme emplacement were low temperature and/or nonreactive with the fragments. One notable exception is in one diatreme on the west coast of Patterson Island, approximately 0.8 km north of the southwest corner of the island. At this location, angular blocks of Keweenawan diabase incorporated into the central part of this diatreme have bleached rims (Photo 11). This feature is best seen at the waterline, where the fragment have been polished by wave action. The bleached margins vary in width from 3 to 7 cm, and the fragments break easily when hammered, suggesting that the alteration has penetrated deeper than the bleached area rimming the fragments. During the course of mapping, numerous large breccia samples, including specimens from the diatreme displaying bleached rims, were collected and subsequently slabbed. The slabbed surfaces failed to disclose visible evidence of fragment alteration. The visible

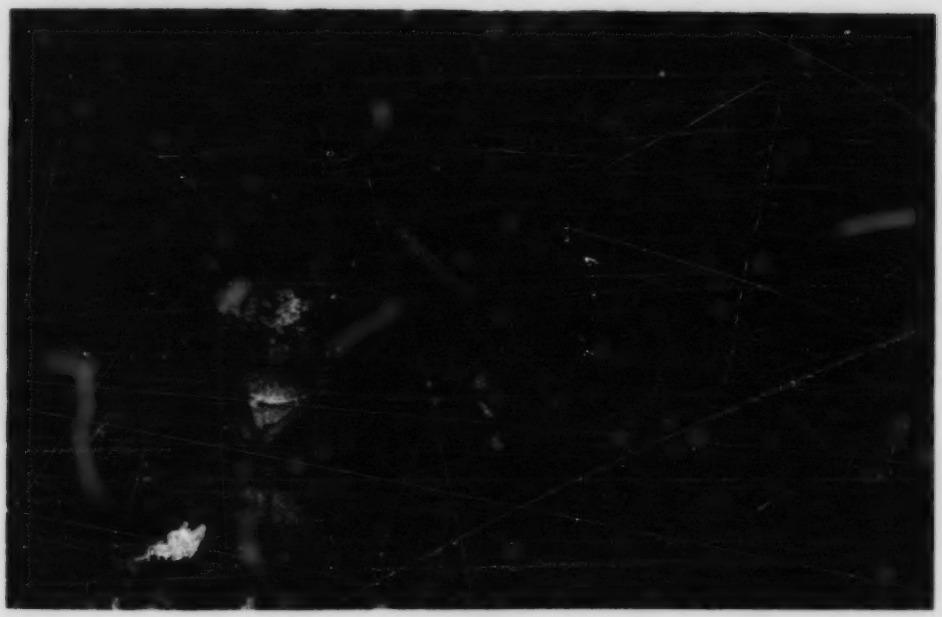

Photo 11. Diabase clasts in centre of one of the larger diatremes on the west shore of Patterson Island. Note the bleaching and alteration along the clast margins. Location P33.

Photo 12. Unusually well developed gradation of fragment size in a diatreme dike on the north side of Spar Island. Photograph taken at lake level. Location P36.

alteration along the rims of fragments from the center of this one diatreme is presumably due to its large size and the greater volume of fluid or gases accompanying it during emplacement. The lack of significant visual fragment alteration in all other dikes would not support the thesis that the hematitic colouration of these breccias is a product of alteration of the iron found in the clastic debris.

The contacts between breccia dikes and host rocks lack any visual evidence of alteration or metamorphism. However, to check the interpretation that alteration or metamorphism did not accompany breccia-dike emplacement, a breccia dike cutting an unmetamorphosed lithologic unit was selected for a comparative study. One thin section was prepared of red alkalic diabase in contact with intrusive diatreme breccia, and a second

thin section was prepared from the apparently unaltered centre of an identical alkalic diabase dike. This was done to compare microscopically the contact effects of the diatremes. The red alkalic diabase at the contact is significantly altered relative to the sample of red alkalic diabase taken from the center of a similar dike. The alkalic diabase in contact with the breccia dike contains saussuritized feldspars, a mafic mineral assemblage altered to chlorite and a reddish-brown iron oxide. Some trace amounts of carbonate and small flakes of biotite are present in the altered rock. The sample from the centre of the red alkalic diabase dike consists of unaltered plagioclase (An_{45-54}), augite, hypersthene, apatite, and magnetite. Other than the effects of relatively low-temperature, low-pressure contact metamorphism of albite-epidote-hornfels facies, there were no differences between the two samples.

The alteration of the red diabase is essentially one of hydration and oxidation. Turner (1968, p.257, 258, 366) indicated that the albite-epidote hornfels facies of contact metamorphism takes place at approximately 300 to 400°C. This temperature range is also typical of the greenschist facies of regional metamorphism (Turner 1968, p.366). Because the Archean rocks represent a water-rich and carbon dioxide-rich sequence of greenschist-facies metamorphic grade, the incorporation of fragments of these rocks into the diatremes under conditions similar to their original metamorphism would not leave a metamorphic overprint. This is likely the reason, in part, that alteration rims were observed on previously unmetamorphosed Keweenawan diabase clasts in the large diatreme along the west coat of Patterson Island, whereas associated Archean clasts within the same dike did not display such visible alteration. Samples of the breccia matrix and enclosing felsic metavolcanics were collected in 1978 and their Ba, Sr, TiO_2, and P_2O_5 contents were compared. These elements are depleted in the breccia matrix relative to the volcanic rocks (Sage 1982). Such alteration was not evident in other breccia matrix–wall rock comparisons on mainland diatremes (Sage 1982) and is likely related to minor leaching by hydrothermal fluids passing through this breccia intrusion.

The general lack of fragment alteration indicates that the hematite present in the breccia is probably not a product of alteration of the fragments entrapped in the diatreme intrusions. In addition, the general lack of extensive fragment alteration would further suggest that the hydrothermal fluids (1) were not at an elevated temperature, (2) escaped rapidly, or (3) were nonreactive, or were the result of a combination of any of these factors. The leaching of Ba, Sr, TiO_2 and P_2O_5 suggests that the fluids were deficient in these elements and not likely directly related to carbonatite magmatic activity.

Fragment Sorting. In general, little sorting of the breccia fragments in the dikes is recognizable. One exception was found on the north side of Spar Island, where a breccia dike 72 cm wide displays a strong gradation of fragment size from fine pulverized rock debris along its flanks to a coarse breccia core, where fragments as large as 5 cm are present (Photo 12).

A second form of fragment sorting was observed in a diatreme breccia along the northeast coast of Patterson Island; here the breccia contains several large angular blocks of Archean rocks, approximately 1 m along a side. The breccia along the side of the blocks displays a size gradation in comminuted rock matrix over a width of 5 cm, with the finest fragmental material in direct contact with the block. The size-graded rock fragments grade imperceptibly into unsorted breccia away from the edge of the block. These forms of fragment distribution are interpreted to be the result of the local presence of laminar flow, similar to the model proposed by Bhattacharji (1967).

A breccia intrusion exposed midway up the west coast of Patterson Island contains a small, very fine-grained irregular dikelet of comminuted rock debris, which is interpreted to be an autointrusion of the fluidized matrix.

Exotic or Anomalous Clasts. One diatreme structure on the southeast corner of Patterson Island contains a large block of Keweenawan amygdaloidal volcanic rock, 1.5 by 2 m, which may have been rafted or collapsed into place during diatreme emplacement. The amygdules are filled with bluish agate. Even though Keweenawan mafic flow rocks are not presently exposed nearby, they were undoubtedly present when the diatremes were emplaced and presumably they presently lie close by and immediately offshore from Patterson Island beneath the waters of Lake Superior.

Halls and Grieve (1976) reported high level material in the Slate Islands diatremes and attributed this to downward intrusion caused by meteorite impact. Such an interpretation is unwarranted in the author's opinion. Hearn (1968) and Snyder and Gerdemann (1965) described stratigraphically high level clasts deep in diatreme structures and this feature could perhaps be considered characteristic of diatremes. McCallum et al. (1976) and Woolsey et al. (1975) have experimentally demonstrated that high level material can occur deep within a diatreme structure after collapse of the fluid column following emplacement. The uranium-thorium mineralized McKellar Creek diatreme located on the mainland northeast of the islands contains abundant fragments of Sibley quartzite whose present nearest outcrop is approximately 65 km west of the diatreme. These fragments likely resulted from collapse of overlying rocks at the time of emplacement.

The presence of an amygdaloidal mafic volcanic block in the diatreme on the southeast corner of Patterson Island is likely the result of collapse of the fluid column subsequent to emplacement. The block likely came from a Keweenawan volcanic edifice that existed over the island and which has been removed by erosion.

Fragments from deep levels were not recognized. Fragments from the steeply dipping Archean rocks could conceivably travel up or down several thousands

of metres and remain unrecognizeable from clasts derived from the immediately adjacent rocks.

Diatreme–Wall Rock Contact. All country-rock–diatreme breccia contacts are vertical to steeply dipping, have wedge-shaped terminations, and have sharp angular corners and edges along the flanks of the dikes, giving the appearance of brittle fractures. The dikes commonly form a ramifying network, and dike orientation is not controlled by the well developed cleavage in the Archean host rocks. This feature was particularly evident on the southeast coast of Patterson Island, where the ramifying nature of the dikes is well displayed beneath the shallow waters of Lake Superior. At this location, the angular fracture pattern is without any obvious control by the strongly anisotropic host rocks, and this implies rapid, sudden emplacement and/or random, non-oriented force of sufficient intensity to override anisotropy in the host rocks. The well-developed foliation in the Archean felsic metavolcanic host rocks at this location would be expected to exert more structural control on diatreme emplacement if the emplacement was at all passive in nature.

The diatreme–wall-rock contact relations therefore suggest sudden and rapid emplacement of the breccias, such as would be necessary for the development of shock features in the host rocks.

Breccia Transporting Fluids. Only indirect inferences can be drawn about the nature of the transporting medium for the breccia dikes. These inferences must be made from chemical and mineralogical changes or alterations in the host rocks. A fluid composed essentially of water and carbon dioxide is likely the most probable transporting medium, and the process of fluidization as proposed by Reynolds (1954) is the most likely emplacement mechanism.

The suggestion that carbon dioxide and water were the medium for diatreme breccia emplacement is inferred from (1) high water and carbon dioxide content of the Keweenawan flow rocks that have been cut by the breccia dikes; (2) presence of carbonate in the diatremes; and (3) development of hornfelsic contact metamorphic effects, not visually apparent, along the diatreme contacts, which are essentially hydration and oxidation effects.

Breccia dikes are abundant in the lower part of the Keweenawan volcanic sequence near the Keweenawan–Archean contact. Even though they were the freshest samples available, analysis of carefully selected amygdule-free, massive mafic volcanic rocks from this sequence show that the average combined water and carbon dioxide content for the five samples analyzed is 8.29% by weight (*see* Appendix A). This is three times the combined water and carbon dioxide reported by McIlwaine and Wallace (1976) from similar rocks of the Osler Group located farther west; these, on the basis of 15 samples, average 2.58% by weight. The Keweenawan mafic volcanic rocks on the Slate Islands have thus been extensively impregnated with water and carbon dioxide. A logical source is the diatremes along the base of the section. In thin section, carbonate veinlets and mineral replacements of feldspar fragments and chips are present in some of the breccia matrix of the diatremes, suggesting the addition of carbon dioxide.

The chemical composition of the Keweenawan mafic flow rocks, thin sections of the breccia matrix, and thin sections of the host rocks flanking the breccia dikes suggest the introduction of water and carbon dioxide, indirectly implying that these fluids accompanied diatreme emplacement. Fluid charged with carbon dioxide would thus appear to be the most plausible transporting medium for the breccia.

Minor element chemical analyses completed by the author in 1978 indicate that this transporting fluid depleted the matrix of the largest diatreme on the island in Ba, Sr, TiO_2 and P_2O_5 (Sage 1982).

Diatreme Breccia and Associated Magmatism. A recognizable igneous matrix is lacking in all samples studied in thin section, and no igneous association can be clearly identified. The relative low temperature albite-epidote hornfels facies of contact metamorphism observed at the breccia dike-alkalic diabase contact suggests relative low temperatures, perhaps below the silicate solidus, and that a magmatic phase was not present at least at the present level of exposure.

Diatreme Genesis. Harris et al. (1970) considered that diatremes are the result of volatile-rich magmas formed at depths of 35 km or greater which have risen to shallower depths and exsolved a gas phase. Because the two phases (gas-magma) of the system occupy a greater volume than the initial magma, a gas pressure greater than load pressure can be created that could be released by failure of the crustal rocks (Harris et al. 1970). On the basis of experimental data, Wyllie and Huang (1976) have predicted a phase transition in CO_2 from liquid to gas in carbonated alkalic magmas ascending from the asthenosphere. This transition would take place at depths of 80 to 100 km.

Adiabatic expansion and exsolution of the gaseous vapours (water, carbon dioxide) would cool the magma, which would solidify before reaching the surface (Harris et al. 1970). Harris et al. (1970) concluded that the gas system escaping at the surface would transport wallrock xenoliths and fill the vents with an agglomeration of volcanic and xenolithic material. However, volcanic fragments that could possibly be related to the diatreme event are lacking in the Slate Islands breccias, even though the mechanism proposed by Harris et al. (1970) would otherwise seem to be applicable to the Slate Island diatremes. The lack of volcanic fragments in the breccia that can be related to the diatreme event suggests that fluid activity accompanying the diatreme event may have had little surface manifestation other than the development of chaotic breccias marginal to the diatreme vents. Any such deposits that were originally present have subsequently been removed by erosion. It would seem that diatreme emplacement need not be accompanied by extensive volcanism and that magmatic activity associated with the diatremes need

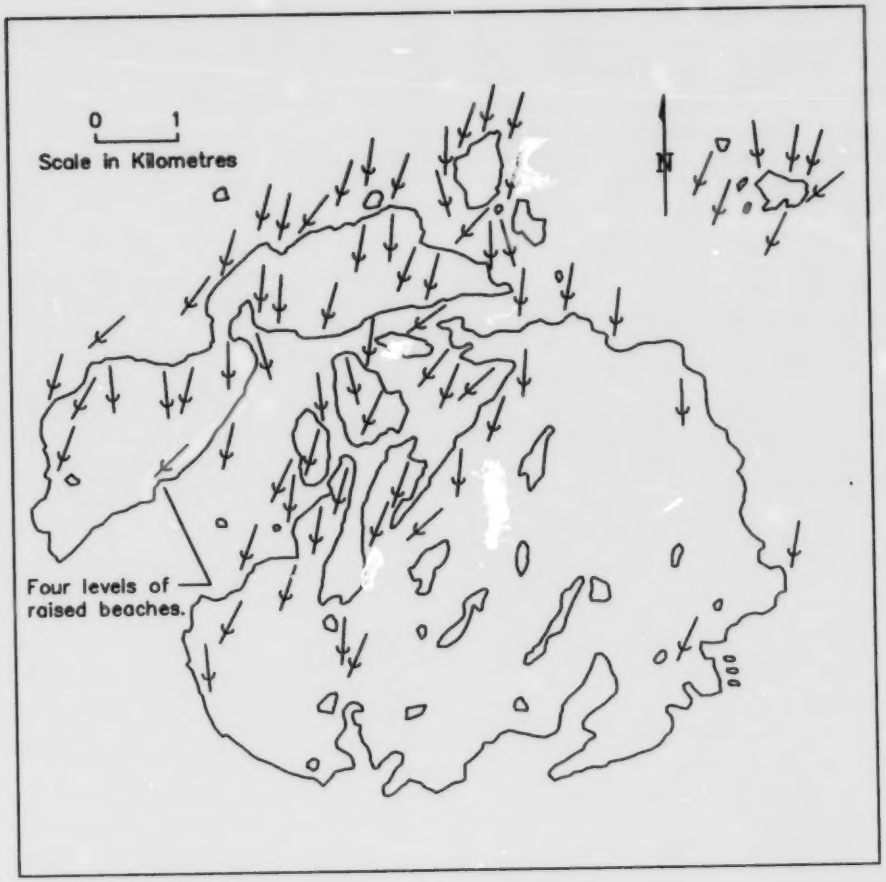

Figure 11. Glacial striae on the Slate Islands.

not have a significant surface expression. In the case of the Slate Islands diatremes, the present level of exposure is above that of any associated magmatic activity.

CENOZOIC

PLEISTOCENE

Patterson Island is noted for its apparent lack of features commonly attributed to glaciation (Parsons 1961), however this is due to the relatively easily eroded schistose nature of the Archean rocks. On the hill tops formed by Archean diorite and Keweenawan diabase dikes and along the coastline where similar rocks are exposed, glacial striae and local grooving are not uncommon. The best examples of glacial grooving and striae are found on the massive, relatively non-schistose Mortimer and Delaute Islands. Figure 11 is a plot of the directions of ice movement as indicated by glacial streamlining of the outcrops and associated grooves and striae. The direction of ice movement is towards the southwest. The massive and relatively more erosion-resistant nature of the mafic volcanic rocks on Mortimer and Delaute Islands have probably acted in part as a shield to the southwest-moving ice sheets and protected the more easily eroded Archean schistose rocks on the more southerly islands of Dupuis and Patterson. Keweenawan dike intrusion of these same islands has undoubtedly also contributed to the protection and prevention of excessive ice erosion of the Archean rocks on these islands. The shielding effect of the mafic intrusions and massive edifice of Mortimer Island in combination with the folded nature of the rocks on Patterson Island have all acted together to impart a circular pattern to the is-

Table 3. Beach elevations above present level of Lake Superior.

	1	2	STAGE
Beach #1	5.7 m		
		10.2 m	Sault
Beach #2	14.4 m		
		32.7 m	Nipissing
Beach #3	49.2 m		
Beach #4	58.8 m		
		63.9 m	Dorion

1 – Readings by D. Bathe, July 1974; elevations measured at crest of beach. The lake level for July was 180.3 plus/minus 0.15 m (Ministry of Transport, Nautical Services, Thunder Bay).

2 – Elevations of glacial lakes from Farrand (1960, p.203, Series 120)

lands at the present level of Lake Superior. On the east side of Delaute Island one outcrop had a very weakly developed set of striae suggesting locally an earlier ice movement from the northwest.

Some of the more spectacular Pleistocene features are the raised beaches along the shores. These beaches are best developed in the more protected coves. The best example of a raised beach is on Mortimer Island approximately 1.5 km east of Barnard Point. At this location there are two beach levels. The beaches are shingle beaches consisting of well rounded, generally flat cobbles and pebbles, in part locally derived, and in part reworked glacial debris. Other than the beaches Pleistocene deposits are essentially absent from the islands.

The beaches near Barnard Point were surveyed by pace-and-compass and altimeter (Table 3). The elevations of the two beach levels and the very vague suggestion of two more were measured to determine their height above the present level of Lake Superior. The elevations are compared (Table 3) with data collected on the mainland by Farrand (1960) at Terrace Bay immediately north of the islands. The beach levels on the Slate Islands do not correlate well with those observed by Farrand (1960) on the mainland.

Wave action by the waters of Lake Superior at its present level has carved the coast into grottos, walls, pinnacles, spires, cliffs, and jagged reefs which makes travel close to the coast hazardous in inclement weather. This wave action along with the highly altered and colourful metavolcanic rocks has created a scenically spectacular coastline with numerous small pocket beaches of sand and gravel.

Metamorphism

ARCHEAN ROCKS

Metamorphism of the Slate Islands rocks is highly variable. Those on Mortimer and Delaute Islands are relatively fresh and locally contain primary minerals while those on the remaining islands are extensively altered. Parsons (1918, p.155) was the first to comment on the highly altered nature of the Slate Island rocks.

> "Considering the accessibility of these islands, remarkably little has been written concerning their geology; in fact so far as the writer is aware, no attempt has been made to differentiate the various types of rock. This is less surprising when one sees the character of the rocks, for with few exceptions they are so decomposed and altered that it is extremely difficult to secure satisfactory specimens for study."

There is a rather impressive contrast in structure, metamorphism (alteration), and character between the various islands. Mortimer and Delaute Islands consist of relatively massive, pillowed, mafic metavolcanics. These rocks are weakly carbonatized, or locally schistose and weather dark green, grey-green, or greenish black.

The remaining islands including those of the Leadman Islands are highly schistose, highly carbonatized, and weather various shades of orange, red, orange-brown, red-brown, pale green, brown, and pink. The submerged area between Mortimer Island and Patterson Island is one of deep water (Map 2303, Canadian Hydrographic Service) and presumably is the locus of shearing and possibly faulting.

Rocks selected from the islands for chemical analysis were selected on the basis of homogeneity, identifiable primary character and minimum alteration. The chemical analyses in Appendix A indicate that a number of the samples from Patterson Island and Leadman Islands contain up to 10% combined CO_2 and H_2O. Since these rocks are the freshest obtainable, the total combined CO_2 and H_2O in most of the rocks on these islands is probably higher. The red-brown, orange-brown weathering of most of the Archean rocks on the islands is largely due to the pervasive presence of carbonate that when occurring in recognizable grains weathers rusty-brown characteristic of iron-bearing carbonate such as ankerite or siderite. The light yellow-brown colour and relatively low iron content of some specimens is probably more indicative of ankerite than siderite.

Quartz veining is generally of narrow width, short strike length, and has no obvious source. Along the southeast coast numerous quartz veins strike normal to schistosity planes and lithologic trends. In the vicinity of the "St. Mary's Bay" gold occurrence, quartz veins have a sinusoidal form which generally parallels schistosity in the host rock. The showings occur in the nose of a southwest-plunging fold in the Archean rocks. The model proposed by Boyle (1961, p.1, 86, 91, 92, 105, 142) of interstitial fluids being mobilized by metamorphic processes freeing silica, and migrating into dilatant zones appears applicable to the observed features on the islands. Carbonate alteration has locally been so intense that dark mafic rocks have been transformed to light coloured rocks which superficially resemble felsic rocks. Particularly intense carbonate alteration of amygdaloidal mafic volcanic rocks has occurred on the west coast of Edmonds Island.

In general, the strong carbonate alteration and associated quartz veining on Patterson and some of the adjacent islands is considered particularly favourable for gold mineralization.

The high degree of carbonatization and hydration of the Archean rocks on Patterson and adjacent islands appear to be in sharp contrast with rocks on Mortimer and Delaute Islands and rocks on the mainland. The altered rocks may be related to the Big Bay–Ashburton Bay fault zone and, if they possess distinctive geophysical characteristics, could assist in tracing the zone.

Mineral assemblages of the Slate Island rocks were determined largely from thin section examination of samples submitted for complete rock analysis. The mineral assemblages in the Archean mafic and felsic rocks are indicative of greenschist facies metamorphic rank. These assemblages are as follows:

Felsic rocks: Plagioclase (An_{35-50}) ± quartz ± sericite ± carbonate ± chlorite ± chloritoid ± epidote-zoisite. Plagioclase compositions in the felsic rocks were determined on moderately to strongly altered plagioclase phenocrysts and mainly ranged from An_{34} to An_{40}. The phenocrysts are fractured, rotated and set in a very fine-grained polygonized groundmass containing abundant sericite, carbonate, and epidote-zoisite. The phenocrysts usually display carbonate and sericite replacement. Fractured grains are healed by coarse-grained carbonate.

Mafic rocks: Plagioclase (An_{35-70}) + chlorite + actinolite + magnetite ± serpentine ± quartz ± leucoxene ± carbonate ± epidote-zoisite ± pyroxene. The mafic rocks of Patterson Island are generally characterized by a plagioclase anorthite content of 35 to 40%. In a number of samples from Mortimer Island the plagioclase ranges to labradorite. Where labradorite is present in the Mortimer Island mafic rocks, a relict pyroxene, identified optically as augite, is also present. The relict mineralogy is confined to thick flow centres or sill-like intrusions. The lithologic contacts which are generally sheared have mineral assemblages more characteristic of greenschist facies of regional metamorphism.

ANIMIKIE ROCKS

The Animikie rocks contrast with the Archean rocks in their lack of penetrative deformation. Primary textures are well preserved. The polygonized or mosaic texture of quartz in the chert samples examined in thin section

indicate that the rocks have been mildly recrystallized or metamorphosed.

KEWEENAWAN ROCKS

Volcanic Rocks

The Keweenawan rocks along the west coast of the Patterson Island represent a highly altered volcanic sequence. The rocks are locally highly sheared and faulted near the base of the section. Five samples of massive mafic volcanic rock were taken from flow centres in the upper and least deformed portions of the section and submitted for total rock analysis to the Geoscience Laboratories, Ontario Geological Survey (*see* Appendix A). The average combined CO_2 and H_2O, and the average specific gravity of these five samples is 8.28% and 2.77 respectively. These results, compared with equivalent averages of 2.58% and 2.88 obtained from 15 samples of Osler volcanic rocks on the Black Bay Peninsula (McIlwaine and Wallace 1976), illustrate the relatively high degree of alteration of the Slate Islands Keweenawan volcanic rocks. The low specific gravity and high volatile content of the Slate Islands rocks with respect to other Keweenawan rocks is a good indication of their highly altered nature.

In thin section the Keweenawan volcanic rocks locally display cataclastic textures and/or fracturing of the mineral grains, patchy replacement of the plagioclase by carbonate, and uralitization of the pyroxenes. The alteration may be related to one or all of the following: (1) migration of carbonate into the Keweenawan rocks from the highly carbonatized Archean rocks; (2) connate fluids; (3) diatreme activity that cut the Keweenawan rocks; and (4) hydrothermal solutions from an unknown source. The author tentatively concludes that the alteration of the Keweenawan volcanic rocks is related to brecciation and volatile migration associated with diatreme emplacement.

The extensively altered Keweenawan flow rocks are characterized by the following mineral assemblage: pyroxene (augite) ± plagioclase (An_{51-69}) ± calcite ± devitrified glass ± pumpellyite ± magnetite ± leucoxene. The thin sections are heavily stained with hydrous rusty brown iron oxides and very fine-grained chlorite and actinolite may be present. The mineral assemblage is of zeolite or lower greenschist facies of regional metamorphism.

DIABASE DIKES

Massive diabase dikes cutting the relatively unaltered volcanic rocks such as on Mortimer Island are fresh in appearance whereas diabase dikes cutting altered volcanic rocks on the other islands display highly variable degrees of alteration. The smaller the diabase or basalt dike the more altered it is. The larger dikes are zoned from altered margins to fresh cores. From field observations this alteration consists of the development of chlorite, actinolite and saussurite which are characteristic of the greenschist facies of regional metamorphism.

The relative ages of dike emplacement could not be established because of lack of crosscutting relations and initially an attempt was made to use relative degree of metamorphism as an indicator of relative age. It soon became evident that metamorphic criteria could not be applied for the relative metamorphism of any given dike was dependent on its size and the volatile content of the rocks it intruded.

Contact metamorphic effects between the diabase dikes and enclosing schists are of a very local nature. Contact hornfels several centimetres in width has developed locally along the margins of some dikes, but it is considered of little importance and was not examined in thin section.

The lamprophyre dike with carbonatitic affinities cutting across the southeast corner of Patterson Island has formed a 5 cm wide contact metamorphic hornfels in the wallrock. This hornfels was not examined by thin section.

A diatreme breccia dike cutting red alkalic diabase was thin sectioned to determine if any reaction or alteration had accompanied its emplacement. As discussed under "General Geology", the breccia-diabase contact indicated contact metamorphism of relatively low temperature and pressure (albite-epidote hornfels facies). The alteration of the red diabase is essentially one of hydration. Presumably the water gained access to the dike via the diatreme breccia which indicates indirectly that diatreme emplacement may have been by fluidization of the breccia with aqueous, CO_2–rich fluids.

SHOCK METAMORPHISM

The geologic significance of shock features in rocks is the subject of considerable controversy. The recognition of shattercone structures and deformation lamellae in quartz grains is taken by a number of investigators to indicate the presence of shock events which they correlate with hypervelocity meteoric impact (Halls 1975; Carter 1968a,b; Bunch 1968; Dietz 1968). Other investigators have examined the same or similar features and even though they agree with the interpretation that a shock event has created the structures they have proposed mechanisms other than meteoric impact (Currie 1966, 1971a, 1972; Bostock 1969; Greenwood 1967; Fudali et al. 1973.

Shatter Cones

Along the west coast of Patterson Island, several shatter cone structures occur within the Keweenawan mafic flow rocks and interbedded siltstones and sandstones (Figure 8, Chart A). These shatter cones are better developed in the lower parts of the Keweenawan section in close proximity to breccia dikes. The shatter cones are scarcer and more poorly defined in outcrops on reefs and shoals farthest from the coast and highest stratigraphically. This trend towards poorer development of shatter cones is in a direction away from the larger and better developed diatreme structures in the lower part of the Keweenawan section close to the Keweenawan–

Archean contact. It thus appears that the shatter cones and diatremes are spatially related. The shatter cones are best developed in the amygdaloidal tops of the mafic flows and in the very fine-grained silty layers of the sandstone interbeds (Photo 13). Shatter cone structures are generally attributed to the passage of intense shock waves through rock (Dietz 1968). Recognizable cone structures also occur in Archean rocks but are much more poorly developed.

Cones within the Keweenawan rocks are generally about 20 cm long and have a well-developed splay of lineations along their flanks (Photo 13). The cones are poorly developed in the coarser sandstone interbeds, which consist of easily disaggregated sand-size grains. One poorly defined cone about 0.3 m long was observed in a specimen of Keweenawan sandstone float on the west coast of the island.

Within the Keweenawan section on the west coast of Patterson Island, strike and plunge were measured on a large number of cone axes. Cone axes were measured using a Brunton compass. The method described by Manton (1965) was not used because neither time nor facilities were available to undertake such a detailed procedure. Recognizable cone structures were measured, and all axes were plotted on a lower-hemisphere stereonet and contoured (Figure 8). The resulting diagram displays a strong maximum approximately 10° below the horizontal and a scatter of of data that would average at best into a horizontal position (Figure 8). The cone axes do not fall along a great circle; thus, considering that the Keweenawan flows dip from 80° west in the lower part of the section to 25° west in the upper part, it is suggested that the shatter cones were developed after the flows were rotated into their present position. This interpretation could be somewhat suspect because bearing and plunge measurements of the axes were made in a limited part of the stratigraphic section immediately above the intense shearing and diatreme intrusions where the cones were available for examination. These measurements are thus confined to approximately 60 m of the 120 m Keweenawan section that is the more shallow dipping.

The cone apices in Figure 8 were plotted on a rose diagram which indicates that the cone-forming event occurred due east or just north of east and toward the interior of Patterson Island.

Shatter cones are recognizable only in the less schistose Archean rocks, and they are not nearly as well developed as in the Keweenawan section. The schistose nature of the Archean rocks of Patterson Island is not conducive to the development of cone structures. The presence of shatter cones in the Archean rocks is indicated by splaying lineations on some fracture surfaces, the crudely conical fracturing of some rock units, and flattened conical fractures with splaying lineations. These structures seldom exceed 4 or 5 cm in length, and their poor development, combined with imperfect cone shape, makes measurements difficult if not impossible.

Poorly developed or crudely inferred shatter cone structures were observed on the southwest coast of Mortimer Island, on McColl Island, and along the south coast of Patterson Island. Some crudely developed shatter cones were identified on the east coast of Patterson Island. K. Treacher (Ontario Geological Survey, personal communication, 1974) reported to the author that there are shatter cone structures on the Leadman Islands. No attempt was made to measure the features in the Archean rocks, but the visual impression is of a highly variable or random orientation. In hand samples, as many as four different cone orientations are recognizable, some of which point in opposite and apparently conflicting directions. The apparent randomness of the cones, in contrast to the consistent orientation in the

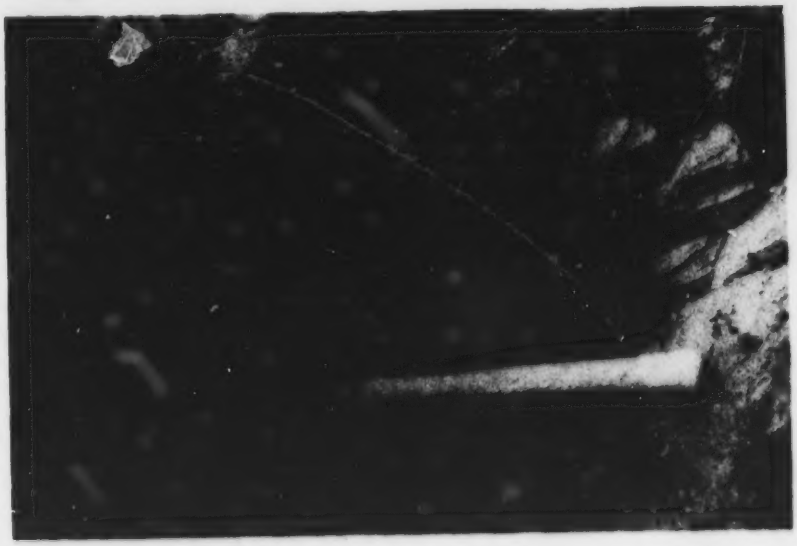

Photo 13. Shatter cone structures in Keweenawan amygdaloidal flow rock. Location P39.

Keweenawan rocks on the west coat of Patterson Island, may be a function of the geometry of diatreme dike emplacement. The east and west coast pattern of breccia dike emplacement forms a wedge-shaped mass relative to Patterson Island. The explosive emplacement of the dikes would make Patterson Island the site of shock-wave collision and reverberations from the west and east coast. Such a shock-wave pattern could account for the apparently random cone structures within and along the east coast of Patterson Island. The diatremes along the west side of the island lie at the base of the Keweenawan section and outside of the wedge-shaped mass forming the bulk of Patterson Island. The consistent pattern in the Keweenawan rocks is thus accounted for by being outside this wedge-shaped mass and thus subjected to only one shock wave without significant reverberations.

Halls (1979b, p.572) recognized the fact that a number of cone sites contained "anomalous" cone orientations with respect to the meteor impact model which he attributed to uplift following impact. Evidence for post-shock uplift was not cited and after carefully selecting cone orientation data and rotation of this data he predicted that the cones pointed upward (Halls 1979b, p.574). Halls (1979b, p.574) proposed that the islands were deeply eroded since the impact event, a conclusion at variance to field observation and a study of deformation lamellae in quartz by Robertson and Grieve (1977, p.700).

Microstructures

A few breccia samples from the diatremes were selected for thin-section examination of the finer-grained matrix. The texture is best described as mortar with angular rock fragments and mineral chips set in a hematite-rich pulverized rock matrix. Some fibrous chlorite is present in the hematite-rich groundmass, and numerous tiny irregular stringers of carbonate cut through the breccia matrix. No igneous matrix was recognized, nor was glass or devitrified glass present in the sections examined. Several thin sections display composite quartz grains, likely chert fragments derived from the Gunflint Formation, with well-developed lamellae, and in one section an abundance of such grains is evident under high magnification (Photo 14). These lamellae appear as a series of parallel lines on the individual quartz grains. At least two sets of lamellae are present on individual quartz grains in the thin section displaying the best development of the feature. These lines appear to have a spacing varying between approximately 0.005 and 0.04 mm. Measurements of the attitude of lamellae relative to the *C* crystallographic axis of quartz were made on 15 composite grains best displaying lamellae (Table 4). These lamellae are similar if not identical to lamellae in quartz grains whose formation has been attributed to a shock event (Carter 1965, 1968a,b; Bunch 1968; Robertson et al. 1968). Several angular plagioclase grains were noted, some with kinked albite twin planes. These grains are generally extensively saussuritized.

In 1977 Robertson and Grieve compared planar deformation features in quartz found at the Slate Islands with similar features found at the Charlevoix crypto-explosion structure in Quebec. Indicated higher pressures at the Slate Islands relative to Charlevoix at proportional distance suggested to Robertson and Grieve (1977) that erosion at the Slate Islands was less than that

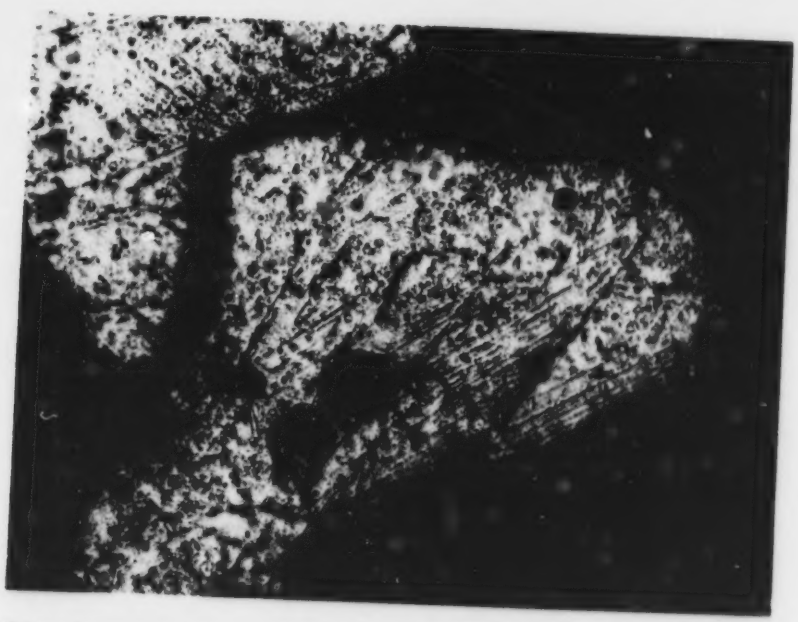

Photo 14. Quartz lamellae in a composite chert fragment from one of the larger diatreme structures on the Slate Islands. Note two directions of quartz lamellae. The fragment was probably derived from the Gunflint Formation. Photo by A.J. Naldrett, University of Toronto. Location P33, (west coast of Patterson Island).

Table 4. Crystallographic orientation of lamellae in quartz from a diatreme breccia on the Slate Islands.

Number of Grains	Crystallographic orientation of lamellae with respect to "C" axis of quartz.
9	(0001)
3	$(10\bar{1}3)$
1	(0001) and $(10\bar{1}3)$
1	$(10\bar{1}3)$ and $(10\bar{1}1)$
1	$(10\bar{1}1)$ and (0001)

Note: Measurements by Darko Sturman, Mineralogist, Royal Ontario Museum.

found at Charlevoix. In addition they proposed that the shock event occurred less than 350 ± 25 Ma years ago. On the basis of field geology erosion has not been deep since Proterozoic time and on the basis of K-Ar isotopic ages on a lamprophyre dike cut by diatreme breccia the shock event is younger than 300 Ma.

Stesky and Halls (1983) expanded the data of Robertson and Grieve (1977) and proposed that the pressure gradient at the Slate Islands was not significantly different from that found at Charlevoix. Stesky and Halls (1983) found a greater scatter of shock pressure than Robertson and Grieve (1977) which they stated required additional study.

Stesky and Halls (1983) used Manton's (1965) method of shatter cone measurements but experienced some difficulty at some sites due to rock anisotrophy. They (Stesky and Halls 1983, p.6) also found "anomalous" cone orientations which did not fit any simple pattern. Stesky and Halls (1983, p.9) predicted that the centre of the shock event was east of Lawrence Bay at an elevation of approximately 1.0 km above the present erosional surface.

The study by Stesky and Halls (1983) is the most complete study of shatter cones on the Slate Islands. Additional work is required to determine the significance of the "anomalous" cone orientations and to obtain a more equal distribution of data.

Origin Of Shock Features

Although a detailed theoretical or historical discussion of the significance of shock features in a rock suite is beyond the scope of this report, a brief discussion of the controversial nature of shock features is warranted.

The recognition of shatter cones and deformation lamellae in quartz grains is taken by several investigators to indicate a shock event that they correlate *a priori* with hypervelocity meteorite impact (Carter 1965, 1968a,b; Bunch 1968; Dietz 1968).

Bucher (1963) and Currie (1965) have documented the fact that several proposed meteorite craters occur on or along major regional geologic structures and cannot be accounted for by extraterrestial meteoric impact. Several crypto-explosion structures within the Canadian Shield typify the present debate between the opposing points of view. Opposing meteorite impact-endogenous process views are given for the Brent crater, Ontario, by Hartang et al. (1971), Dence (1968), and Currie (1971b). More recent mapping of the area of the Brent crater supports Currie's (1971b) interpretation (S.B. Lumbers, Royal Ontario Museum, personal communication, 1977). Lumbers (1977, personal communication) and Currie (1971b) related the Brent structure to alkalic magmatism along the Ottawa–Bonnechere graben system.

The astrobleme-endogenous debate about the Sudbury Basin, Ontario, has been summarized by Dence (1972), French (1968, 1972), Dietz (1972), and Card and Hutchinson (1972). Card and Hutchinson pointed out that the regional tectonic and stratigraphic setting of the Sudbury structure involves a number of features that are inconsistent with a meteorite impact origin. Aspects of the astrobleme versus endogenous origin for Sudbury are presented in a series of papers within *"The Geology and Ore Deposits of the Sudbury Structure"* (Pye et al. 1984).

A summary of opposing views regarding the formation of the Clearwater complex, near Quebec, can be found in the articles by Bostock (1969), Dence et al. (1974) and Dence (1968). Bostock (1969) proposed updoming over a magma chamber, explosive devolatization of a volatile-rich magma, and collapse along radial and ring fractures for the Clearwater Lake structures.

Currie (1972) investigated the Manicouagan resurgent caldera in Quebec, a structure classified by some as an astrobleme (Robertson and Grieve 1975), and concluded that the structure was related to faulting, alkalic magmatism, and caldera-style collapse.

The disagreement between the two schools of thought is a result, in part, of different approaches to the same problem. Those proposing endogenic processes base their conclusions on field observations and field data, while those proposing astrobleme origins support their hypothesis with the recognition of shock metamorphic features and the *a priori* assumption that such features can be caused only by meteoric impact.

Proposals for the meteoric impact hypothesis lack an explanation for closely associated local and regional structures, discussed by the previously cited authors, and associated evidence for magmatic activity.

The correlation between geologic structure and crypto-explosion structures was first summarized by Bucher (1963), and an adequate explanation for this relationship in the context of meteoric impact has yet to be made. The debate, astrobleme versus endogenic process, applies directly to the Slate Islands. Halls (1975, 1976), Robertson and Grieve (1976), Halls and Grieve (1976), Grieve and Robertson (1976, 1977) and Halls and Stesky (1978) have proposed meteoric impact in the Slate Islands, however, these discussions have neglected local geology and the regional setting of the islands. As previously discussed, the islands occur at a unique location marginal to the Lake Superior Basin. The possibility of a meteorite impact at this precise loca-

tion—on a ridge traversing the Lake Superior Basin, on the nose of an Archean fold structure, at the precise location of the Proterozoic–Archean contact, at the precise location of two intersecting regional faults, and at the precise location of highly volatile alkalic magmatism—is too incredible to accept. A meteoric impact at this precise location could be explained as fortuitous, but the occurrence of all of these conditions at once would be well beyond normal circumstance. Therefore, in the author's opinion, the meteoric hypothesis must be rejected as a viable answer to the shock metamorphic structures found on the island.

Halls and Grieve (1976) have used the explosion-impact studies of Stoffler (1972, 1974) to define the conditions of shock metamorphism found in the Slate Islands. While these studies undoubtedly have applicability to acknowledged meteorite impact scars such as the Barringer crater in Arizona, the use of such data to explain the shock features on the Slate Islands appears unwarranted; it is necessary to examine the islands in light of their regional geologic setting. Making the *a priori* assumption that shock features represent hypervelocity meteorite impact is, in the author's opinion, incorrect when it fails to explain the geology as it appears in the field. The structure and magmatic history of the islands are more consistent with endogenous processes, and the experimental data of Stoffler (1972, 1974) would not apply. The petrologic studies of Wyllie and Huang (1976) involving volatiles in the mantle may have direct application, but much experimental work must still be done to more closely define the physical-chemical conditions of magmatic processes that give rise to shock metamorphism.

From the many lines of geological and geophysical evidence, meteoric impact as the cause of the Slate Islands shock features is considered to be highly unlikely. The shape, structure and shock features found on the islands can be accounted for by endogenous processes rather than extraterrestial missiles. The diatreme event is an integral part of the geologic history of the Southern Province of the Canadian Shield and the development of the Lake Superior Basin.

Summary Of Data Supporting Endogenic Origin Of Shock Features

Subsequent to the author's mapping of the Slate Islands (Sage 1974, Sage et al. 1975) many articles have appeared in various journals advocating or accepting a meteorite origin for the islands (Halls 1975, 1976; Robertson and Grieve 1976; Halls and Grieve 1976; Greive and Robertson 1976, 1977; Halls and Stesky 1978; Stesky and Halls 1978). The author (Sage 1978b) criticized this concept and a review of these points now appears warranted as well as updating existing data. The reader should also refer to the structural geology section of this report for clarification of these points concerned with structural geology. The Slate Islands are sited at a structurally unique position with respect to the Lake Superior Basin.

Regional and Local Setting

1. The islands occur at the junction of two geophysically inferred faults (Hinze et al. 1968) which on the basis of geological observation by the author and previous work by Halls (1972) are likely to have existed since Keweenawan–Archean time.
2. The islands occur on the Keweenawan–Archean regional contact.
3. The islands represent a fold nose in Archean rocks.
4. The islands occur on a topographic ridge traversing the Lake Superior Basin in a northeasterly direction. Based on Halls (1972) data and basin analysis by White (1972) the ridge existed prior to Keweenawan time and because of the absence of Animikie rocks east of the islands may have existed in Animikie time.
5. Highly volatile-rich alkalic magmatism occurred along the northwest-trending fault zone (Big Bay–Ashburton Bay fault) which served not only as a controlling influence on alkalic rock-carbonatite magmatism north of Lake Superior but also controlled the setting of an earlier period of diatreme activity (Keweenawan) on the mainland immediately northeast of the islands (Sage 1978, 1982).
6. The islands lie along a trend of unusually thick crust. Using seismic data Smith et al. (1966) postulated a crustal thickness of more than 55 km southwest of the islands along trend of the Big Bay–Ashburton Bay fault and Mereu (1965) postulated a crustal thickness of approximately 45 km at Marathon, Ontario, approximately 50 km northeast of the islands. The geologic setting of rifted thick crust is very favorable for magmatic activity of an alkalic nature (Bailey 1974a,b).

Geological Observations

1. The presence of clast size sorting in the diatremes from fine-grained margins to coarse-grained centres as seen on Spar Island and along margins of large clasts on the east side of Patterson island is typical of laminar flow (Bhattacharji 1967) more likely to occur within diatremes rather than with instant downward intrusion by impact.
2. The presence of contact metamorphic effect between diatreme breccia and alkalic diabase and alteration rims on clasts in the largest diatreme structure found on the west side of Patterson Island indicates that hydrothermal activity accompanied or followed breccia emplacement which is inconsistent with impact origin.
3. The presence of coarse fragmental rocks in the Archean and plotting of flow directions in Keweenawan flow rocks combined with the abundance of Keweenawan dikes on the islands suggest the islands have been the site for volcanism during Archean and Keweenawan time. The islands are a logical site for subsequent volcanic-diatreme activity.

Geological Problems with Impact

1. Halls and Grieve (1976) attributed the circular form of islands to impact. In addition to the fact that the islands occur on a fold nose the circular form can also be influenced by the presence of numerous massive Archean and Keweenawan intrusions which shielded the less resistant rocks from glacial erosion. Also glacial striae suggest a deflection of ice around Patterson Island by the massive bulk of Mortimer Island.

2. Halls and Grieve (1976) suggested downward intrusion of the Slate Islands breccias as supporting downward intrusion by impact. However, experimental work by McCallum et al. (1976) and Woolsey et al. (1975) indicates that the presence of high level clasts low in a diatreme structure results from collapse of the fluid column following diatreme emplacement. Also, the presence of stratigraphically high fragments deep in diatremes is common if not characteristic of diatremes (Snyder and Gerdemann 1965; Hearn 1968).

3. Halls and Grieve (1976) stated that volcanic explosions cannot generate pressures sufficient to create shock features found on the islands. This statement is based on the work of Gorshkov (1959) who studied one volcanic explosion. Such limited sample population does not warrant such a conclusion. Colgate and Sigurgeirsson (1973) calculated a mixing model of lava and water which would generate catastrophic explosions at pressures that would generate shock features. In addition, high pressures do occur in the earth, and in kimberlite structures, which are often described as diatremes, pressures are sufficient to generate coesite (Smyth and Hatten 1977).

4. Halls and Grieve (1976) and Robertson and Grieve (1977) compared the Slate Islands shock features with those of the Charlevoix structure in Quebec. The Charlevoix structure occurs on the St. Lawrence Valley rift which would allow such comparison with the Slate Islands; however this does not establish impact for the Slate Islands or for either structure. Such comparison would be more appropriate if made with a less questionable structure such as Barringer Crater in Arizona.

5. Halls (1979a) implied that a younger age proposed by Robertson and Grieve (1977) for the diatreme event on the Slate Islands relative to the age of other alkalic events within the area does not support an endogenous origin for the shock event. Alkalic rock carbonatite magmatism spans 800 Ma along the Kapuskasing Structural Zone (Gittins et al. 1967) and 600 Ma along the St. Lawrence graben system (Doig and Barton 1968), thus age is irrelevant in distinguishing endogenous from meteorite origin.

6. Halls (1979a) used clast rounding as means of distinguishing conglomerates from breccias, however clast rounding or round clasts are common in mainland diatremes adjacent to the Slate Islands (Sage 1978a).

7. Halls (1979a) and Robertson and Grieve (1979) implied that the lack of igneous matrix indicates a non-endogenous source or origin. In the case of the Cane Valley diatreme, McGretchin et al. (1973) suggested emplacement at temperatures below the silicate solidus. Reid et al. (1975) suggested that extrusive rocks at Igwisi Hills, Tanzania, which are kimberlitic, were extruded below the silicate solidus and Harris et al. (1970) concluded that adiabatic expansion at the time of explosion may solidify any associated magma at depth. In addition, the author has mapped all presently known diatreme structures northeast of Lake Superior (Sage 1978a, 1982) and with the possible exception of two or three outcrops on the Deadhorse Creek structure an igneous matrix is lacking. The Deadhorse Creek outcrops displaying possible igneous matrix consist of silicocarbonatite (biotite plus carbonate) with altered xenolithic wall rock fragments. The presence or absence of an igneous matrix at the present level of exposure does not preclude an igneous origin.

8. Halls and Grieve (1976) and Halls (1979a) cited cone studies in support of impact and gave average orientations of cones, but did not give sample populations or standard deviation or mean. Also they failed to indicate if all cones or a select few were measured at each site or the criteria for selection. In an area of highly variable cone orientation and rock anisotropy, an adequate sample population is needed.

9. Halls (1979a) suggested convergence of shatter cones or shock towards the centre of Patterson Island, however, the geometry of the islands and diatreme dikes indicates an increase in shock towards the centre of Patterson Island and shock reverberations likely caused the variable cone orientations observed at sites within the island. Patterson Island is a wedge shaped block lying between loci of diatreme activity along the west and east coasts, therefore cone orientations converging towards the centre are to be expected.

10. Halls (1979a) implied that singularity in event supports impact. The author has mapped all diatreme structures presently known in the area without finding evidence for multiplicity of emplacement.

11. Halls (1979a) suggested that the present fold structure represented by Patterson Island is the result of impact. The shock event and assumed folding would therefore have to the latest event on the islands. If this were true, all lithologic units should display similar structural fabric and metamorphism. The penetrative schistosity of the Archean contrasts sharply with the open structures found in the Animikie and Keweenawan. The metamorphic grade (greenschist facies) of the Archean also contrasts with zeolite to lower greenschist of the Keweenawan.

12. Halls (1979a) suggested that some tilting of the Keweenawan sequence has taken place since the shatter cones were created. Tilting, if present, could be tectonic as well as being related to impact. Halls would have to establish criteria separating the two.

13. Halls and Grieve (1976) and Robertson and Grieve (1979) cited experimental evidence in support of impact origin for the deformation lamellae in quartz (Stoffler 1972, 1974). Baeta and Ashbec (1967) have produced similar features at atmospheric pressure and Hobbs et al. (1972) have documented the effect of OH on synthetic quartz. The presence of OH significantly lowers the pressures required for lamellae development. The experimental work cited in support of impact has the following shortcomings:

a) Those advocating impact have not disproved the tectonic-petrologic model by investigating petrologic systems.

b) Impact models have not been conducted on polycrystalline rock materials.

c) Impact models ignore grain boundary effects.

d) Impact models have not studied the effects of fluid along grain boundaries and within the shock minerals themselves.

e) Chao (1968) cited initial volume or porosity, grain size, modal mineral composition, compressibility or shock impedance, thermal conductivity of surrounding phases, presence of water, and pressure of voids as all having a likely effect on lamellae development. These parameters remain to be fully evaluated.

Petrochemistry

During the course of mapping, samples were routinely collected for chemical analysis. These samples were selected on the basis of (1) homogeneity, (2) relative freshness, and (3) recognizable lithology. In general highly schistose rocks were avoided since original lithology could not be determined and samples of the pyroclastic rocks were collected only from the central portion of the larger fragments. The samples thus collected should give the most representative data regarding differentiation trends. Petrographic descriptions, major and minor element analyses, and norms are given in Tables A–1 to A–4 (Appendix A).The reference numbers for the samples are plotted on the accompanying map (back pocket). All analyses were done by the Geoscience Laboratories, Ontario Geological Survey. Norms were calculated by the method of Irvine and Baragar (1971).

The samples analysed were the freshest obtainable but often even these contain up to 10% combined CO_2 and H_2O, (exclusive of Mortimer Island). Such extensive alteration would affect major and trace element chemistry. Consequently the following discussion of trends in rock composition or classification of the lithologies must be taken in this context. A large number of samples were analyzed because of the early recognition of the problems associated with such a highly altered rock sequence.

ARCHEAN ROCKS

Figure 12 is an AFM diagram of all the analyses of Archean rocks and shows a predominantly calc-alkalic trend. The data was also plotted on diagram of normative plagioclase vs Al_2O_3 (Figure 13). In this plot the samples show a broad distribution in both the tholeiitic and calc-alkalic fields with no apparent grouping.

In the AFM diagram shown in Figure 14, only the felsic volcanic rocks are represented and this diagram shows a moderately well defined clustering of the data into two groupings. One group cluster towards the alkali apex of the diagram while a second group plots towards the centre. The cluster towards the alkali apex largely represents samples from the southern and south-western flank of Patterson Island and a series of coarse pyroclastic rocks. The cluster towards the centre of the diagram is largely representative of the felsic volcanic and feldspar porphyry flow rocks found within the centre and along the northern flank of Patterson Island. These two areas are separated by a thick sequence of amygdaloidal flow rocks and probably represent two, or parts of two, separate felsic cycles of volcanism.

An AFM plot of the mafic metavolcanics on Mortimer Island and Patterson Island (Figure 15) shows little compositional difference between the two rock groups. There is a slight suggestion that the Patterson Island rocks may be more andesitic in nature, but the much greater degree of alteration of the Patterson Island rocks could account for this slight difference.

Thick sequences of feldspar porphyry on Patterson Island were interpreted to be sill-like intrusions emplaced into the volcanic sequence concomitant with volcanism. There may by a genetic relationship between the porphyritic intrusive rocks and the numerous feldspar-porphyritic flow rocks on the islands. The most notable difference in the field between these two rock classes was the higher concentration of feldspar crystals in the flows compared to the intrusions. The flows commonly contain more than 50% feldspar crystals in contrast to a general maximum of 30% for the intrusive rocks. Chemical analyses of these rocks plotted on an AFM diagram (Figure 16) indicate a clustering of points representative of the intrusive rocks and a large scatter of points for the extrusive rocks. The association of more primitive extrusive rocks and more differentiated felsic intrusive source rocks which have been emplaced into their own more primitive effusive products is a feature characteristic of more recent plutonic-volcanic inter-relationships (Hamilton and Myers 1967). The author is of the opinion that the feldspar porphyry flows are likely the more primitive effusive equivalents of the feldspar porphyry intrusives.

Two quartz-feldspar intrusive rocks were also plotted on Figure 16 but these two bodies may not be a part of the feldspar porphyry intrusion-flow relation. These quartz-bearing bodies are more massive and much less penetratively deformed than the feldspar porphyries and thus may represent a somewhat later Archean intrusive event.

Parsons (1961) on the basis of the high feldspar content of some of the flow rock, suggested that some of the units may be trachytic in composition. A graph comparing the total alkalis vs silica content of the metavolcanics (Figure 17) indicates that the Archean metavolcanics are subalkalic in nature.

KEWEENAWAN AND PALEOZOIC ROCKS

The Keweenawan igneous rocks are represented by flow rocks and mafic intrusive dikes. The flow rocks are not well represented on the islands, being confined to a 120 m section on the west coast of Patterson Island. The dikes pervasively intrude the Archean sequence on the islands and one dike cuts the lower portion of the sequence of mafic flow rocks. The flow rocks are highly altered and contain in excess of 8% combined CO_2 and H_2O which is more than three times the average content in a similar sequence of Osler volcanic rocks on the Black Bay Peninsula (Halls 1974; McIlwaine and Wallace 1976).

An AFM plot (Figure 18) and a plot of normative plagioclase composition vs Al_2O_3 (Figure 19) display well the tholeiitic nature of the flows and the overlapping compositions of the diabase dikes. This is consis-

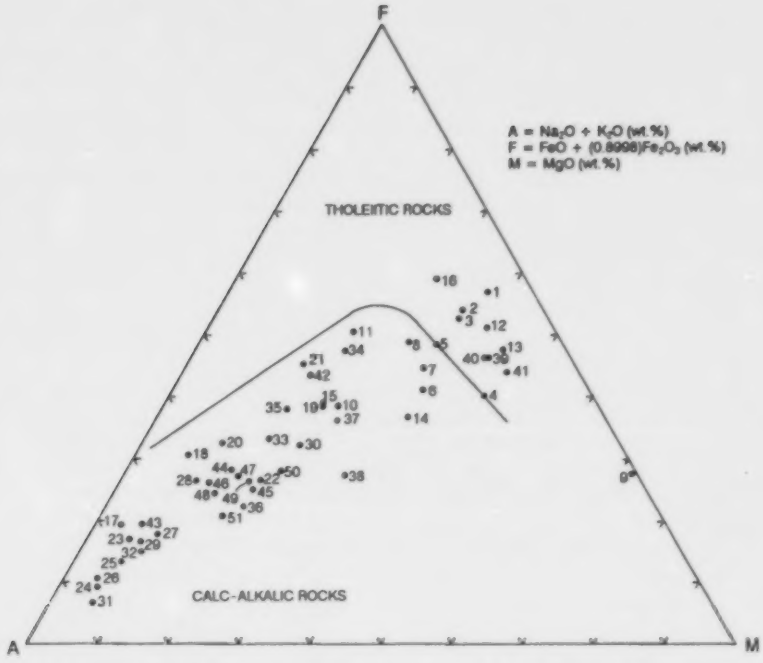

Figure 12. AFM plot for all analyses of Archean rocks of the Slate Islands. A = K_2O + Na_2O, F = FeO (total), M = MgO.

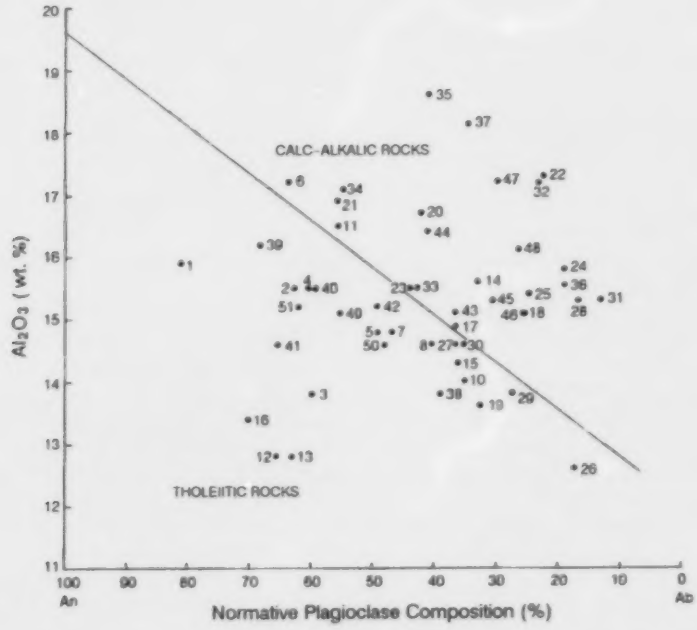

Figure 13. Plot of normative plagioclase composition vs Al_2O_3 for all analyses of Archean rocks of the Slate Islands.

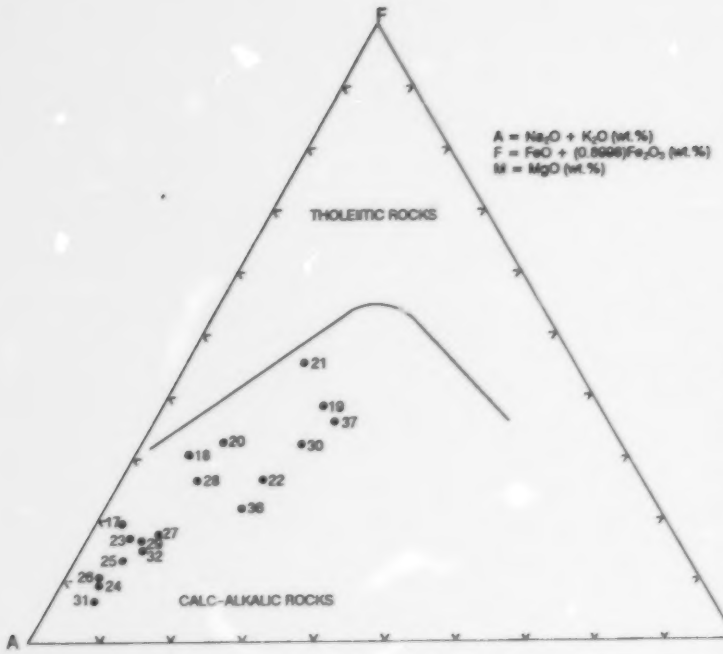

Figure 14. AFM plot of analyses of Archean felsic metavolcanics from Patterson Island and adjacent islands. A = K_2O + Na_2O, F = FeO (total), M = MgO.

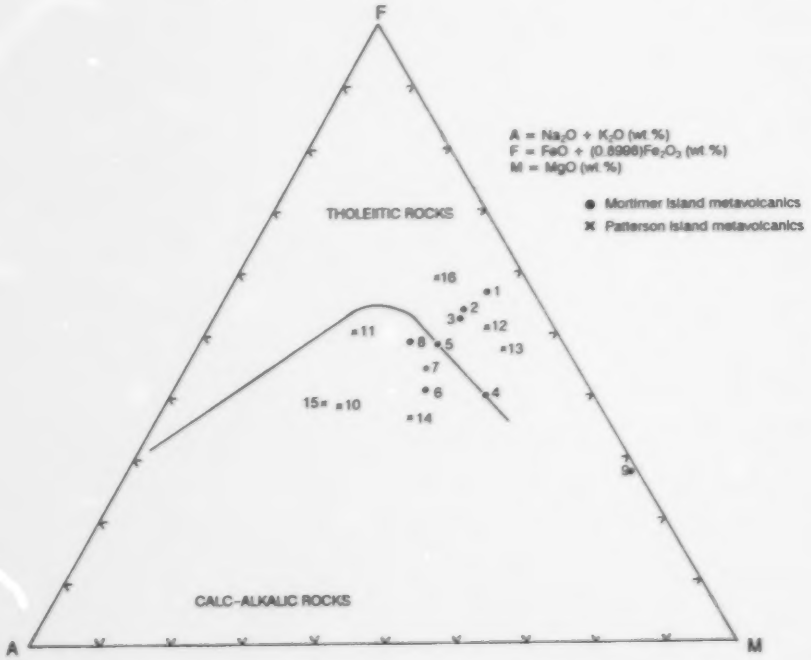

Figure 15. AFM plot of analyses of Archean mafic metavolcanics from Mortimer Island and Patterson and adjacent islands. A = K_2O + Na_2O, F = FeO (total), M = MgO.

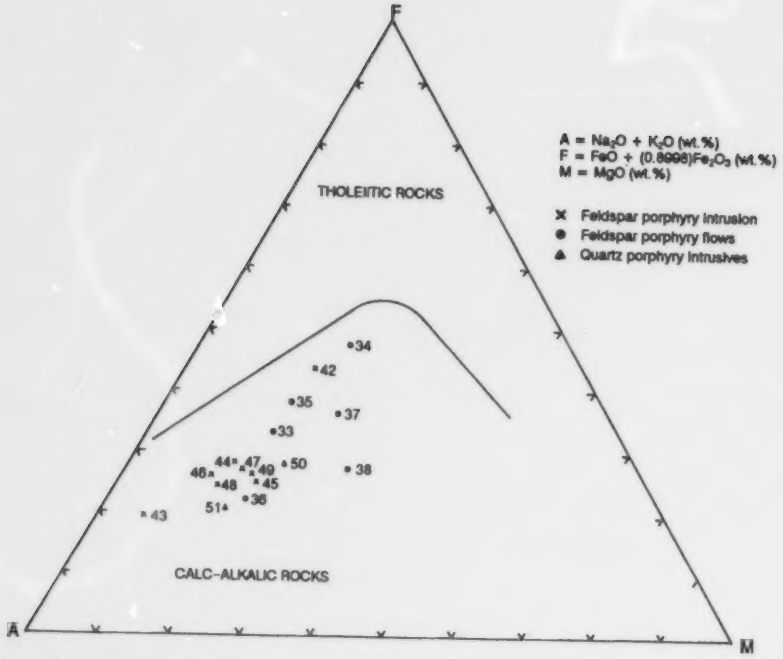

Figure 16. AFM plot of analyses of Archean feldspar-porphyritic flow rocks and feldspar-porphyritic intrusive rocks. A = K_2O + Na_2O, F = FeO (total), M = MgO.

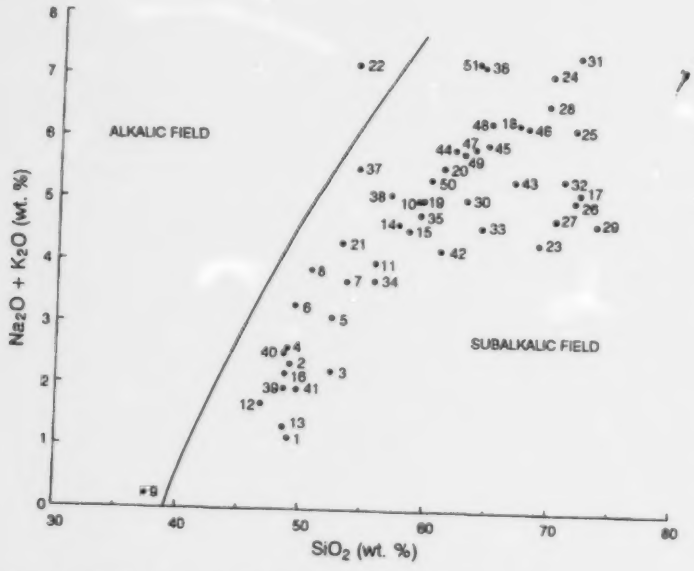

Figure 17. Plot of Na_2O + K_2O vs SiO_2 for all analyses of Archean metavolcanics of the Slate Islands.

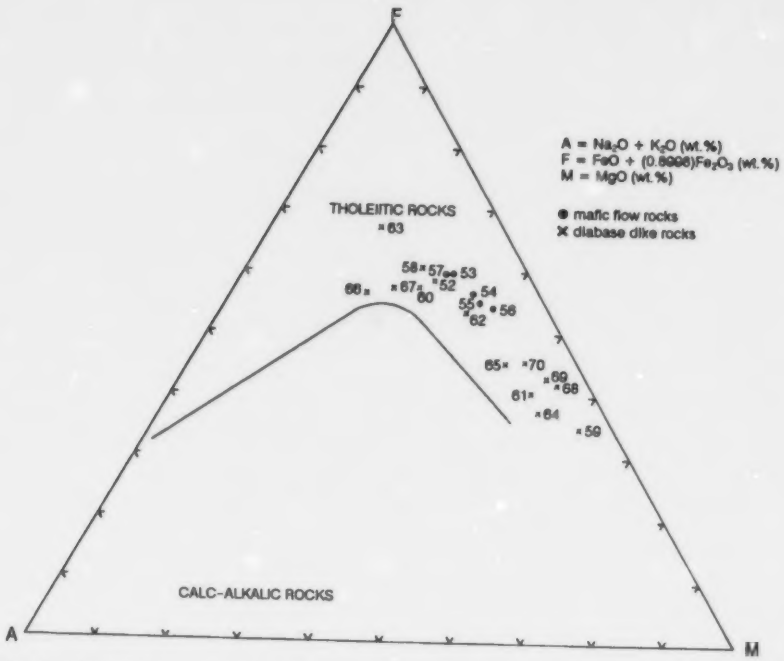

Figure 18. AFM plot of analyses of Keweenawan mafic flows and diabase dikes, Slate Islands. A = $K_2O + Na_2O$, F = FeO(total), M = MgO.

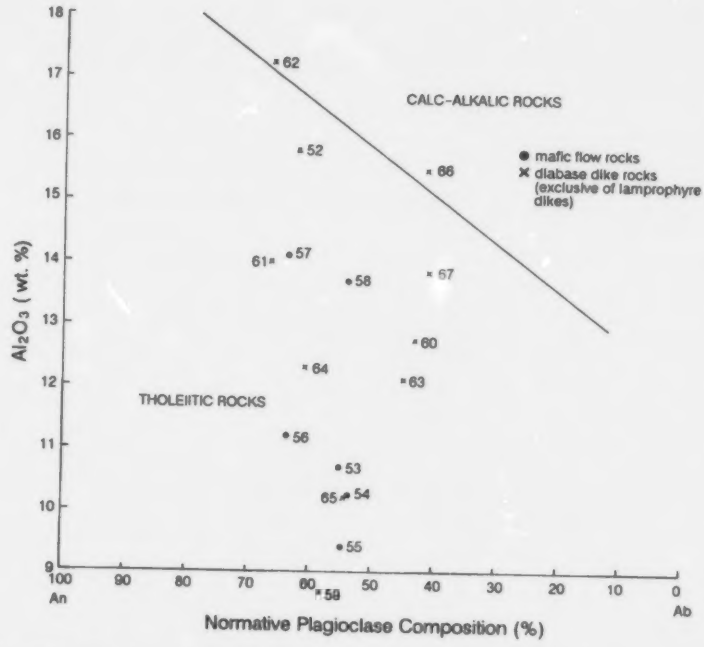

Figure 19. Plot of normative plagioclase composition vs Al_2O_3 for analyses of Keweenawan flows and diabase dikes of the Slate Islands.

tent with the author's proposal that the diabase dikes were the feeders for the flows.

Samples 66 and 67 on Figures 18 and 19 are red alkalic diabase and may be somewhat younger in age than the normal diabases. The major element composition of these samples is similar to the other diabase dikes with the exception of anomalously high potassium and phosphorus. In addition, the barium and strontium contents are 4 to 5 times higher than those of normal diabase. The author has not been able to locate any reference in the literature to the this type of dike on the mainland opposite the Slate Islands. The alkalic nature of the rock suggests strongly that it is related to a period of alkalic magmatism, probably the magmatic events associated with the Port Coldwell alkalic intrusion.

Samples 68 through 70 represent a lamprophyre dike of Pennsylvanian age which has carbonatitic affinities. This dike trends northeast across the southeast corner of Patterson Island. Chemical analyses indicate that the dike rock is strongly silica-undersaturated, has a high potash to soda ratio and high phosphorus and titanium content. These chemical traits are typical of lamprophyric and some carbonatite rocks. In addition, a high volatile content for the magma from which the dike was derived is indicated by its mineralogy and is considered typical of rocks of this type. The high volatile content of combined H_2O and CO_2 is reflected in the presence of abundant phlogopite and carbonate in thin section. On the basis of textural and mineralogic criteria the carbonate is considered to be a primary mineral phase. The carbonate is interstitial, and except for olivine, the minerals are relatively fresh. Texture and mineralogy are typical of some silicocarbonatite rocks examined by the author from the Prairie Lake Carbonatite Complex. Anomalous niobium and rare earths in two of the samples checked for these elements adds further support for the lamprophyre-carbonatitic classification. As with the red alkalic diabase this rock is correlated with the alkalic rock-carbonatite petrogenetic province north of Lake Superior even though considerably younger in age. The age relationship between the red alkalic diabase and lamprophyre are unknown, however they probably represent two independent events separated in time.

Structural Geology

Early in the field season it became apparent that structural features on the islands, and those indicated to be present between the islands, were very complex and that only a preliminary investigation could be attempted within the scope of this project. The penetrative schistosity on Patterson Island is a characteristic feature of most of the islands. Deep water and breccia zones along the flanks of Mortimer Island indicate that tectonic forces have had a strong influence on the present form of the islands. A significant factor in this structural complexity is undoubtedly the fact that the islands occur at the junction of two geophysically inferred regional faults that cut the Lake Superior Basin (Hinze et al. 1966).

FOLDING

The lack of primary structures useful for the determination of stratigraphic attitudes is a serious handicap in unravelling the true nature of the fold structures on the island. As a consequence of meager facing directions, the following interpretation of folding and fold planes should be taken as tentative and subject to modification with additional work. The author suggests that the Slate Islands rocks were originally isoclinally folded into a northeast-trending structure conformable with the isoclinally folded Archean supracrustal rocks on the mainland and described by Walker (1967). This interpreted northeast-trending isoclinally folded sequence was then refolded around a steeply southwest plunging fold axis which is reflected in the northwest-trending lithologies along the west side of Patterson Island. The presence of the southwest-plunging fold structure is inferred from three lines of evidence: (a) lithologic trends as established in mapping by this party and by Parsons (unpublished data); (b) a possible top determination on the northwest corner of Patterson Island in northwest-trending lithologies in which clasts of a rock of one unit are found in an adjacent unit implying tops to the northeast; and (c) the presence of two schistosities along the west coast of Patterson Island, of which one is interpreted to be a rotated S1 and the second axial planar (S2). The author has not observed evidence for a possible second period of deformation in other 'greenstone' belts where a single period of deformation is typical; two schistosities were not observed on the east side of Patterson Island in similar lithologic units. The presence of this southwest plunging fold was first recognized by Nichols (1963, p.16). He proposed that the fold was an anticline, however, reliable facing data is usually lacking making the proposed anticline unconfirmed. An anticlinal structure is thought by the author to be likely but requires facing data to be confirmed.

The folding giving rise to the second schistosity is thought to be very local in nature and a reflection of the proximity of the islands to the intersection of the two regional faults of Hinze et al. (1966). The minor folds (see accompanying map) on the north side of Patterson Island and on islands between Mortimer and Patterson Islands are indicated by lithologic trends and to a lesser degree by schistosity trends and have been superimposed subsequently on the regional fold pattern and the southwest-plunging second period fold. Possible tectonic adjustments between the islands concomitant with folding of the lithologic sequence around the steeply southwest plunging fold axis or at a later period in response to regional adjustments associated with geophysically-inferred, nearby regional faults has likely resulted in the development of the minor folds between the islands. The trends of the projected traces of the axial planes, which are based on lithologic and schistosity trends (Figure 20) show a variation in direction from a north of east trend for the fold on Dupuis Island, to a southeast trend for the fold between McColl and Bowes Islands, to a general north-south trend for the folds on the northwest corner of Patterson Island. This variation is consistent with a clockwise rotation of the fold attitudes resulting from a southerly movement along the west side of the Big Bay–Ashburton Bay fault in agreement with the suggested left lateral offset of Hinze et al. (1966). These interpreted folds therefore may have resulted from the tectonic interaction between the lithologic sequence on Mortimer Island and the one on Patterson Island. As a suggestion, perhaps this rotation of the fold axis is the result of drag or resistance between the two islands, the contact of which is undoubtedly the loci of extensive faulting and shearing. The extensive brecciation along the south coast of Mortimer Island, and the deep trench indicated on hydrographic maps between Mortimer and Edmonds, McColl and Bowes Islands, is a result of this tectonism between Mortimer and Patterson Islands.

The one reliable stratigraphic facing direction (red chert clasts in a slump deposit overlying the presumed unit from which they were derived) occurs within northwest-striking units on the northwest corner of Patterson Island and indicates that the stratigraphy faces northeast. This suggests that the rocks in this part of Patterson Island have their stratigraphic tops facing northeast. Whether these rocks are part of an antiform or a synform with respect to Mortimer Island could not be determined because the rocks on Patterson Island are likely in fault contact with those on Mortimer Island as indicated by the deep water between the islands. Due to the highly deformed nature of the Patterson Island rocks and the lack of well developed primary structures useful for structural analysis, the absolute delineation of the form of the major fold structure on the island may be unresolvable.

On Dupuis Island a minor fold structure (Figure 20, fold 3) may be indicated by the changing attitude of schistosity planes in the felsic metavolcanics. Along the north side of Dupuis Island the schistosity strikes southwest and along the south side strike southeast. In addi-

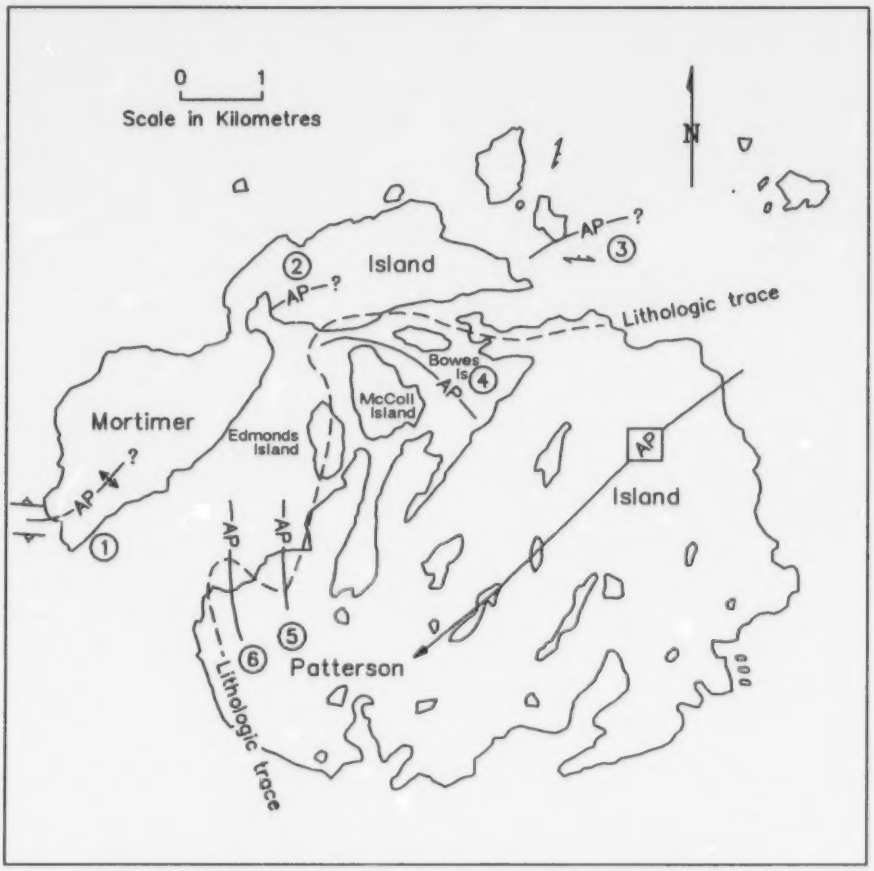

Figure 20. Traces of axial planes of mapped and inferred fold structures on the Slate Islands. Numbered folds are discussed in text.

tion, the on-strike extension of the mafic volcanic rocks on the east side of Mortimer Island impinges on the felsic rocks of Dupuis Island implying that faulting and/or folding has taken place between the east side of Mortimer Island and Dupuis Island. The possible trace of the axial plane of this inferred fold is roughly east. On the east half of Mortimer Island an inferred anticlinal structure (Figure 20, fold 2) is an extrapolation of the anticlinal fold axis defined by pillow facing directions along the west coast of Mortimer Island. A fold axis may also pass through the narrow neck of land between Lambton Cove and Lake Superior on the north side of Mortimer Island. The presence of this fold is suggested by the shape or outcrop pattern of the island and is perhaps an extension of fold 4 (Figure 20). This possible axis is not shown on the map and a diabase dike striking roughly east at the north end of Lambton Cove may occupy the proposed fold axis or lie parallel to it.

On the west half of Mortimer Island pillow tops suggest an anticlinal structure (Figure 20, fold 1). This is the best defined fold structure on the island. The trace of the axial plane of this fold trends east, swinging to the northeast but the axial plane likely swings east to possibly northeast conformable with bedding attitudes in argillite units along the south coast of Mortimer Island and the general form and outline of the island.

Anticlinal folds 1 and 2 (Figure 20) are believed to be folds characteristic of the regional southwest-trending folds on the mainland (Walker 1967) which have been possibly accentuated in later tectonic events. It is possible that the Patterson Island lithologies were shoved against those of Mortimer Island. This is consistent with the left lateral offset of the major, geophysically inferred, regional faults that intersect offshore from the islands (Hinze et al. 1966). The fault offset of the Michipicoten Island fault by the Big Bay–Ashburton Bay fault would require a southerly movement of the western side (Hinze et al. 1966). This tectonism would result from the southerly movement (compression) along the west side of the Big Bay–Ashburton Bay fault inducing extension in a northwest-southeast direction (compression for Mortimer Island lithologies) resulting in additional buckling or folding of the Mortimer Island rocks.

Lithologic trends and attitudes of schistosity on Bowes and McColl Islands suggest that these two islands represent opposing limbs of a fold structure with the trace of the axial plane passing in a northwest direction between the islands (Figure 20, fold number 4). The

lack of stratigraphic data prevents an interpretation as to the nature of this suggested fold. A possible fold is proposed at the narrow neck between the eastern and western portions of Mortimer Island which lies near the apex or at the extension of fold 4 (Figure 20). The outcrop pattern at this narrow neck suggests some inflection of stratigraphic trends.

On the northwest corner of Patterson Island two possible north-trending axial plane traces are indicated (Figure 20, folds 5 and 6), based on the correlation of amygdaloidal mafic flows (map unit 1) on the northwest corner of Patterson Island with those 1.2 km east of the point on the north coast of Patterson Island, with those on "Amygdaloid Island" and with those on Edmonds Island. A partially traceable volcanic breccia unit within this sequence gives some support to this lithologic correlation and subsequent fold interpretation. Minor inflections in schistosities would tend to support this speculative fold interpretation.

Schistosities on Leadman Island have a pronounced southwest trend while those on the east coast of Patterson Island have a north of east to east-west trend. Folding and/or faulting may thus exist between the two islands.

FAULTING

Positive evidence for faulting on a major scale is absent or not readily apparent on the islands, however brecciated outcrops, sharply contrasting lithologies and linear areas of deep water between some islands imply major faults or shear zones (Figure 21). On Patterson Island minor faulting was observed within a number of Archean units with displacement being generally of 10 to 30 m. The age of these faults is uncertain. The youngest recognizable fault on the islands is a minor fault of about 6.0 m offset which cuts a diabase sill intruding Keweenawan mafic flow rocks. Along the upper surface of the flows is an intrusive breccia related to an early diatreme event. The diabase sill is most likely Keweenawan in age and therefore this movement is later than the Keweenawan, perhaps Pennsylvanian and associated with the later diatreme forming event. Faulted and or sheared diabase dikes were noted on the north coast of Mortimer Island (east half), southeast coast of Delaute Island, and on the south coast of Patterson Island. Many

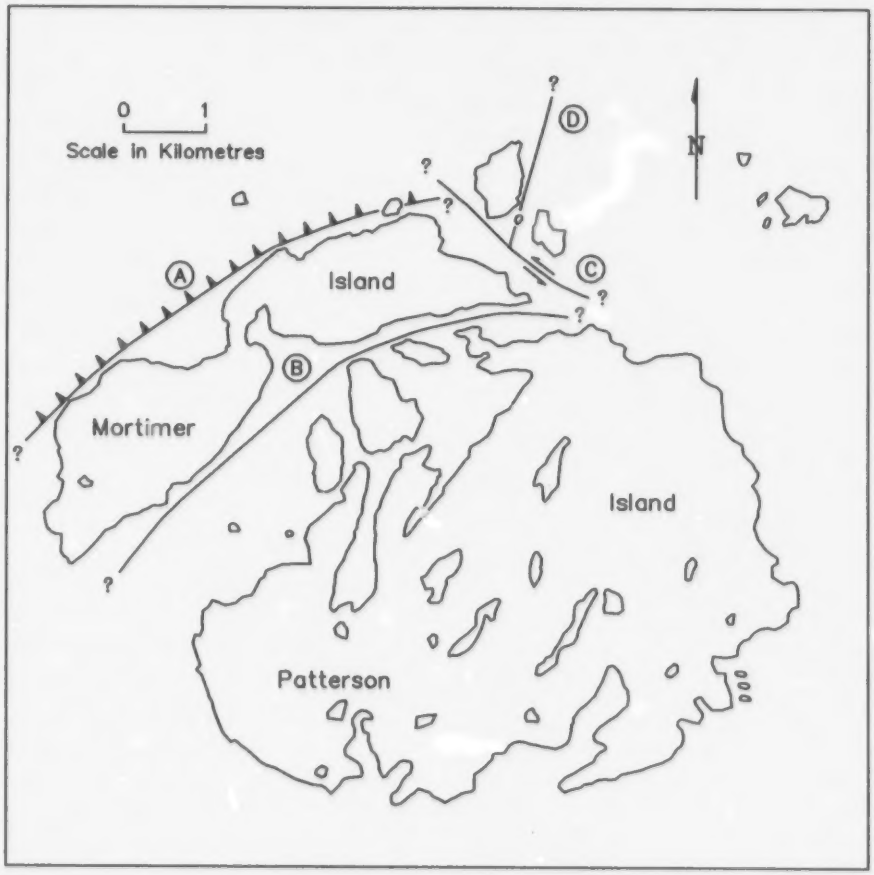

Figure 21. Schematic diagram of larger fault and shear zones interpreted to exist adjacent to islands of the Slate Island group. Lettered features are discussed in text.

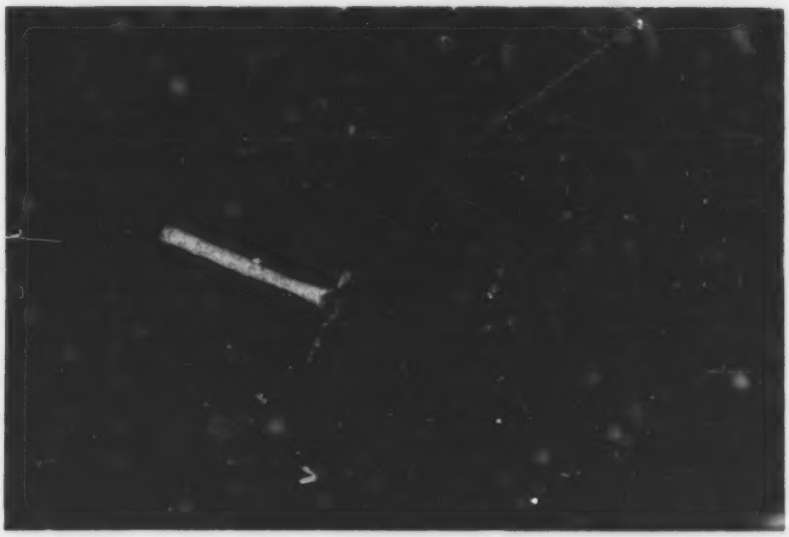

Photo 15. Brecciated mafic metavolcanics typical of numerous areas of the north coastline of Mortimer Island. The breccia is interpreted to be the result of a low-angle, north-dipping fault along the north side of Mortimer Island. Location P44.

other areas also display evidence of sheared and faulted diabase dikes which are considered by the author to be associated with Keweenawan volcanism. This shearing and faulting is post-diabase in age or the result of ongoing dike emplacement and deformation. With ongoing deformation the older dikes would have undergone the most extensive deformation.

Extensive brecciation along the west and east coasts of Mortimer Island suggests that both the east and west sides are the locus of faulting and shearing. The south side of Mortimer is highly sheared with steeply to vertically dipping breccia zones parallel to the coast (not shown on accompanying map) (B on Figure 21). Along the north coast of Mortimer Island numerous exposures of shallowly north dipping breccias imply low angle faulting or thrusting along the north side of the island (A on Figure 21) (Photo 15). Rove Formation underlies "Caribou Point" and therefore this interpreted fault zone may in part define an unexposed Animikie–Archean contact. This generally low angle fault may be a thrust fault in response to northwest-southeast compression. This extensive brecciation combined with the deep water indicated on bathymetric charts suggests that Mortimer and Patterson Islands are in faulted contact. The deeper water between the interior islands of Edmonds, McColl, and Bowes also suggests that perhaps faulting and/or shearing has taken place between them as well. Extensive brecciation along the east side of Mortimer Island, the presence of felsic metavolcanic rocks on Dupuis Island opposite mafic metavolcanics on Mortimer Island, and the presence of younger Rove Formation argillite on Delaute Island lying opposite mafic metavolcanic rocks of Mortimer suggests a fault along the east side of Mortimer Island (C on Figure 21). Possible lithologic offset suggests left-lateral movement. Brecciation along the south and east side of Delaute Island suggests a fault or shear zone in this area (D on Figure 21).

The northwest trending lithologies along the west coast of Patterson Island which define the fold forming Patterson Island have a trend subparallel to the geophysically inferred (Halls and West 1971) offshore Michipicoten Island Fault. Movement on the Michipicoten Island Fault may have helped in folding the supracrustal rocks found on Patterson Island.

The extensive brecciation between the sequence of Keweenawan mafic flows and Archean rocks on Patterson island may be due to faulting or shear movement along bedding planes and locally may be due to diatreme emplacement.

Nichols (1963, p.29) proposed that a left lateral fault existed between McGreevy Harbour and St. Mary's Bay. This fault was not confirmed during mapping of Patterson Island.

SHEARING

Shearing is common in the Slate Islands rocks and defines schistose and/or breccia zones along which offset cannot be detected. Shearing was probably a major feature during development of folds in the Archean rocks on Patterson Island and the surrounding islands exclusive of Mortimer and Delaute.

The penetrative nature of the shearing on Patterson Island is best illustrated along the southwest coast of the island where a mafic volcanic breccia unit lies in contact with a pillowed volcanic unit. The contact between the two units is strongly shear folded; the amplitude of the shear folds is on the order of 1 to 2 m, giving a serrated (saw tooth) or sharply interdigitating contact relationship (Photo 16). The clasts in the breccia are highly

Photo 16. Shear folding along contact between mafic volcanic breccia and pillowed metavolcanics. Amplitude of shear folds is 1–2 m. Location P5.

elongated in the plane of schistosity (S2), which trends at nearly right angles to the lithologic strike, and the pillow structures have been largely obliterated. Minor faulting occurs parallel to the schistosity trends (S2) causing minor offsetting of the lithologic units. Such a penetrative deformation which results in minor faulting and the intertonguing nature of the shear-folded contacts makes the tracing of lithologic units difficult if not impossible without abundant outcrop. This penetrative deformation is characteristic of all the islands except Mortimer and Delaute.

Both Delaute and Mortimer Islands abound with relatively narrow shear zones along their exposed coasts. The precipitous and rugged coastlines of these islands are in part a function of selective erosion of these shear zones which generates cliff faces, alcoves, and grottos along the coast. Some of these shears on Mortimer and Delaute Islands appear to have slight offset relations and thus are approaching faults in definition. The generally insignificant amount of displacement involved would indicate that they best be classed as shears.

Figure 22 is a contoured stereonet plot of 259 shear planes. The relatively large number of maxima make interpretation rather subjective either with or without field observations and any one trend may reflect more than one shear type. Much additional work remains to fully unravel the tectonic implications of the shearing and the interpretation presented is at best only a preliminary one which additional work may modify. The shearing is thought to be largely late Archean in age. It is derived from a north-south compression resulting from extension in a northwest-southeast direction as a consequence of compression in the northeast-southwest direction due to left lateral movement along the west side of the Big Bay–Ashburton Bay fault (Hinze et al. 1966). Some adjustment probably took place along these same shears during the Keweenawan and perhaps later during the diatreme event in post-Pennsylvanian time.

The direction S_0 is the general regional trend of lithologies however there is considerable variation in this trend between Delaute Island and the west coast of Mortimer Island. Some folding of the sequence is likely in the Lambton Cove area and on the west coast of Mortimer Island. The lithologies have been gently folded into a trend just north of west.

Shear direction S_1 trending N43°E and dipping on the average 82°S is likely one set of a conjugate set of shear planes. Shear directions S_2 (N52°W, dipping 59°S) and S_3 (N25°W, dipping 64°N) likely represent the other shear trend of the conjugate set. These two trends would average N38°W with a vertical dip. The strong single northeast trend and two less definitive northwest trends corresponds to a pattern found in Keweenawan diabase dike trends and kink band planes. The conjugate shears are nearly 90° apart and have likely been rotated as a result of deformation. This rotation may account for the two northwest trends as perhaps being either the result of (1) a slip-lock mechanism, or (2) rotation of the first-formed shear to such a degree that it could not relieve the stress and a second set was formed.

Shear direction S_4 (N03°W, vertical dip) is thought to represent shearing along the direction normal to extension which originally was oriented parallel to the compressive stress. In all probability this shear direction has been rotated. The early direction of compression is more likely northwest-southeast and normal to the later southwest-northeast compression resulting from the southerly movement along the west side of the Big Bay–Ashburton Bay fault. A clockwise rotation of approximately 15° for S_4 is likely, making S_1 and S_2 the original conjugate set of shear planes. The rotation was caused

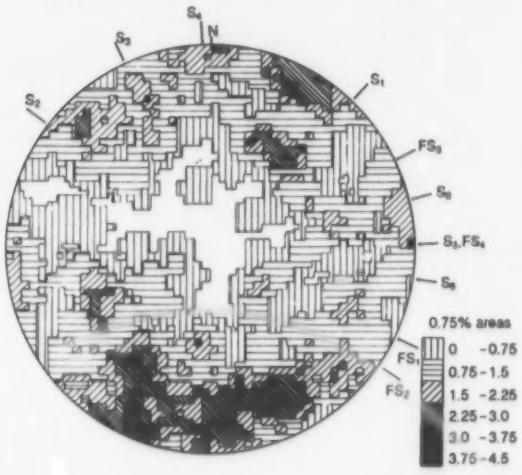

Figure 22. Contoured stereonet plot on lower hemisphere of shear zones on Mortimer and Delaute Islands; total 259 points. S_0 is the general trend of lithologic units; S_1, S_2 and S_3 are conjugate shears; S_2 and S_3 are different orientations of the same set; S_4 is shearing in the direction of extension, rotated; S_5 is in part strike-slip shearing along bedding planes and in part axial planar shearing (southwest coast of Mortimer); S_6 is low-angle, north-dipping shearing principally along north coast of Mortimer Island. FS_1 and FS_2 are strike-slip shearing along west coast of Mortimer Island; FS_3 is strike-slip shearing on Delaute Island and east portion of Mortimer Island; FS_4 is strike-slip shearing along south coast of Mortimer Island and in part steeply dipping axial planar shearing along southwest coast of Mortimer Island. FS_4 and S_5 are represented by the same shear plane and thus difficult if not impossible to distinguish.

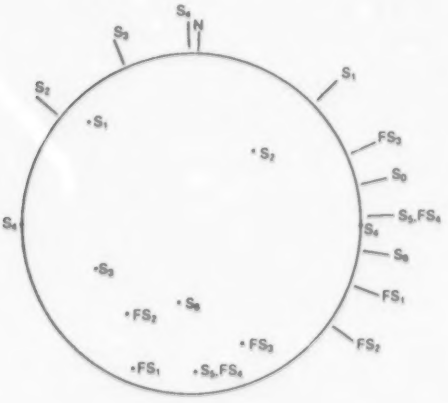

Figure 23. Simplified plane and pole diagram from Figure 22.

by tectonic interaction between Mortimer and Patterson Islands resulting from southwest movements along the west side of the Big Bay–Ashburton Bay fault as suggested by the fault pattern of Hinze et al. (1966).

Shear direction S_5 (N86°E, dipping 82°S) actually represents two types of shear planes. On the southwest corner of Mortimer Island this shear direction is conformable with the trend of the axial plane of the anticlinal folding on this portion of the island as well as lithologic trends. This FS_4 or S_5 is also parallel to a pos-

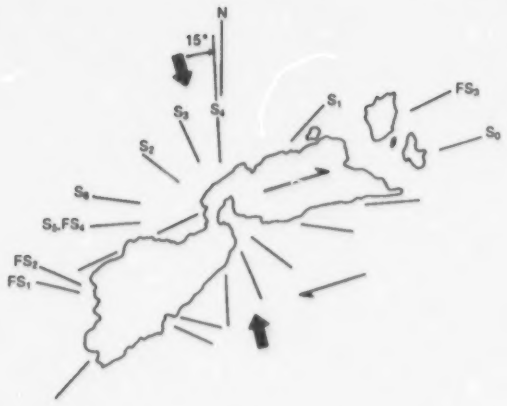

Figure 24. Superposition of shear pattern on Mortimer and Delaute Islands. The relative movements of Mortimer and Patterson islands form a couple.

sible fold axis in the narrow neck of land separating the east and west ends of Mortimer Island north of Lambton cove. This trend is occupied by a diabase dike at the north end of the cove. Extensive nearly vertical shearing occurs along this axial planar trend particularly between the metasedimentary-metavolcanic units on the southwest corner of the island. On Delaute Island the S_5 trend is a strike-slip shear (FS_4) parallel to lithologic trends.

Shear direction S_6 (N87°W, dipping 50°N) represents a shallow north-dipping shear direction which is locally very well exposed along the north coast of Mortimer Island. As indicated on Figure 21 this shear zone likely parallels the coast of Mortimer Island trending southwest. The approximately east-west trend on the stereonet is likely biased due to the larger number of readings in the central part of the island. This shear trend likely resulted from the thrusting of Patterson Island against Mortimer Island which also influenced the development of the anticlinal structures found on the island. The observed evidence for compression and thrust faulting on the Slate Islands is considered by the author to be a local feature related to regional faults and cannot be evidence for crustal shortening in Archean terrains.

Strike-slip shears FS_1 (N66°W, dipping 85°S) and FS_2 (N56°W, dipping 66°S) resulted from bedding plane slips between and along lithologic units along the west coast of Patterson Island due to bedding plane adjustments during folding. At the west end of Mortimer Island the general northeast-trending lithology has been gently folded into a north-of-west trend. Where shear planes are present, slippage or shearing displays a preference to argillaceous interflow beds.

Strike-slip shear FS_3 (N64°E, dipping 75°S) is the general trend of shearing parallel to lithologic trends on the eastern portion of Mortimer Island and on Delaute Island.

In summation, the shear pattern on Mortimer and Delaute Islands is complex and without first-hand field

observations the contoured stereonet would be difficult if not impossible to interpret. Because of the complexity of the diagram representing shear folds (Figure 24) the interpretation given above can be considered only as a basis for future work which may result in significant modification. The shear pattern on these two islands resulted from a local stress system caused by movement along regional fault(s). The shear pattern is interpreted by the author to be the result of northwest-southeast compression, extension in the northeast-southwest direction, followed by northeast-southwest compression as a consequence of left lateral movement along the Big Bay–Ashburton Bay fault as implied by the geophysically interpreted fault pattern of Hinze et al. (1966). Perhaps the fault trending from Michipicoten Island to Schreiber and lying immediately southwest of the Slate Islands served as a buttress to this left lateral movement generating a northeast-southwest compression and consequently extension in a northwest-southeast direction. This extension would result in compression on Mortimer and Delaute Island lithologics. This stress system is likely of late Archean age possibly coeval with folding of the Patterson Island lithologies around a steeply southwest plunging fold axis and the generation of the minor fold structures between Patterson and Mortimer Islands. That an Archean age for this folding and related shearing is likely can be inferred from the absence of a penetrative schistosity in the Animikie rocks. The development of a penetrative schistosity with folding is a characteristic feature of the Archean rocks on the islands. Of particular interest are the similar trends of shearing (Archean), diabase dikes (Keweenawan), and kink bands (Keweenawan) all of which are in the northwest direction, implying Keweenawan stresses were of the same general orientation as Archean.

SCHISTOSITY

One of the most noticeable features of the Slate Islands is the penetrative schistosity within the rocks on most of the islands. Such strong deformation is absent from the rocks on Mortimer and Delaute Islands where massive unfoliated rocks are typical. Undoubtedly the highly fissile rocks on Patterson and other islands originally gave the island group the name of "Slate Islands".

The term *schistosity* is used to define a foliation imparted to the rock by the preferred orientation of micaceous minerals. The dominant schistosity is northeast-trending, and conformable to lithologic trends on the east coast and sharply crosscutting on the west coast. Along the west coast two schistosity trends are recognizable and two schistosities are commonly recognizable in the complexly folded rocks lying between Patterson and Mortimer Islands.

Schistosities on the east coast of Patterson Island (Figure 25) display a strong parallelism with lithologic trends. Presumably this schistosity is an Archean feature developed by extension in essentially the vertical direction (Schwerdtner 1974) concomitant with down

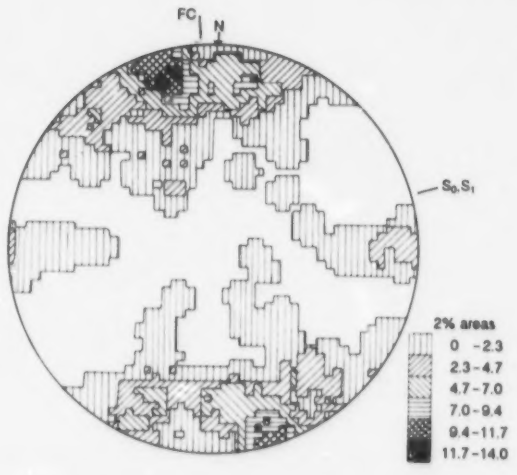

Figure 25. Contoured stereonet plot on lower hemisphere of schistosities on the east coast of Patterson Island. S_0 represents original lithologic trends; S_1 initial schistosity; and FC fracture cleavage; total of 117 data points.

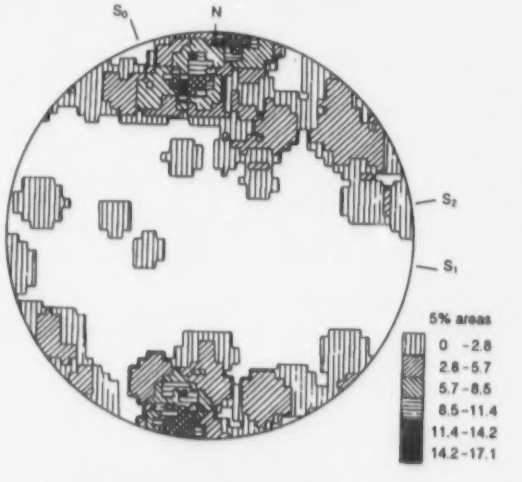

Figure 26. Contoured stereonet plot on lower hemisphere of schistosities on west coast of Patterson Island. S_0 represents original bedding; S_1 original schistosity; S_2 axial planar schistosity; total of 57 data points.

sagging of the supracrustal rocks coeval with volcanism as is typical of Archean terrains (Sage et al. 1975).

Plots of schistosities on the west coast of Patterson Island (Figure 26) indicate that S_1 has been rotated considerably (approximately 60°) with respect to the original bedding (S_0). Imposed upon these two structural trends has been an S_2 foliation which is axial planar and strikes parallel to the presumed Archean northeast-southwest fold structure postulated by analogy with structures on the mainland (Walker 1967) and present on Patterson Island. Schistosity S_2 on the west coast is parallel to S_1 on the east coast. This second schistosity

(S_2) is interpreted to be representative of a late Archean tectonic event that was concomitant with the folding that created the northwest-trending lithologic trends along the west side of Patterson Island. This event also developed the minor folds, on and between Mortimer and Patterson Islands. This S_2 foliation is as highly penetrative as the earlier S_1 and is not typical of the Animikie Gunflint Formation which has only a broad open-fold structure. The lack of the S_2 schistosity in the Gunflint dates the schistosity as pre-Gunflint and presumably late Archean. Since the smaller fold structures located between Mortimer and Patterson Islands also display a penetrative S_2 schistosity it is presumed that they, as well as the Mortimer Island folds, were created during this late Archean event.

The recognition of this late Archean folding-shearing event infers that the regional faults of Heinz et al. (1966) were likely active in Archean times. The topographic, geophysical, stratigraphic and structural features along the Big Bay–Ashburton Bay fault trend are also Archean features that have had a pronounced influence on the regional geology within and marginal to the Lake Superior Basin since that time (Hinze et al. 1966; White 1972; Halls 1972; Smith et al. 1966; Hough 1958).

FRACTURE CLEAVAGE

The Archean rocks commonly display a fracture cleavage which is defined as a set of closely spaced joints or fractures generally less than 2.5 cm apart which often impart a crumbly fracture to the rock when broken. These fractures are not defined by any preferred mineralogical orientation even though some carbonate may occur along the closely spaced hair line fractures. Along the east coast of Patterson Island where the stratigraphy is less deformed than along the west coast, this cleavage invariably occurs at or nearly at right angles to S_1 and normal to the direction of clast elongation. Some, but not all measured fracture cleavages were plotted on the stereonet (Figure 25) of schistosities on the east coast of Patterson Island (only fracture cleavages for which S_1 data available was used). These plots illustrate the tendency for fracture cleavages to occur normal to S_1 which is also normal to the direction of clast elongation. This apparent correlation of fracture cleavage with clast elongation suggests that this fracture is related to the initial Archean deformation which gave rise to S_1 and elongated the clasts. The fracture cleavage is thus an extensional feature of Archean age. One minor trend for Archean mafic dikes also parallels this trend.

On an outcrop of rhyolite breccia along the southeast coast of Patterson Island, an accidental mafic fragment in the breccia displays a series of offsets with the northeast side of each fracture moving northwest with respect to the southwest side (left lateral offset). The fractures are approximately 1 to 2 cm apart and displacement is on the order of 0 to 1.5 cm. This feature was mapped as a slip cleavage. It is uncertain as to whether the displacement along the parallel fractures is Archean in age or the result of the re-activation of the Archean fracture cleavage by a later tectonic event.

Fracture cleavage was also noted in numerous exposures along the northeast corner of Patterson Island. In this area the cleavage occurs at an oblique angle to the schistosity and presumably it has been rotated during folding along the west coast of Patterson Island and between Mortimer and Patterson Island.

CLAST ELONGATION (LINEATION)

Clast elongation is particularly well developed along the southwest coast of Patterson Island in the various pyroclastic units and is present along the east coast even though less obvious and therefore much harder to measure.

A stereonet plot of the clast elongations which is heavily weighted to the southwest and southern part of Patterson Island indicates a plunge of approximately 60° in a S70°W direction (Figure 27). This plunge direction is confirmed by the one exposure of pillowed mafic metavolcanics that occurs on the southwest coast of Patterson Island. The pillows in this one outcrop are highly attenuated and have long axes which correspond closely to the above trend. The pillows are too highly deformed to give a reliable top indication even though a questionable reading was made and is indicated on the accompanying map.

Some of the clast elongation features are undoubtedly related to the Archean event that gave rise to the S_1 schistosity. This event is concomitant with down sagging of the supracrustal rocks coincident with volcanism and extension in a vertical direction (Schwerdtner 1974). However, the stronger, more clear clast elongation in the southwest corner of Patterson Island would suggest that this feature developed in this area when the rocks were folded from their presumed original southwest trend into a northwest trending sequence along the west coast. This folding is of late Archean age. The nose of

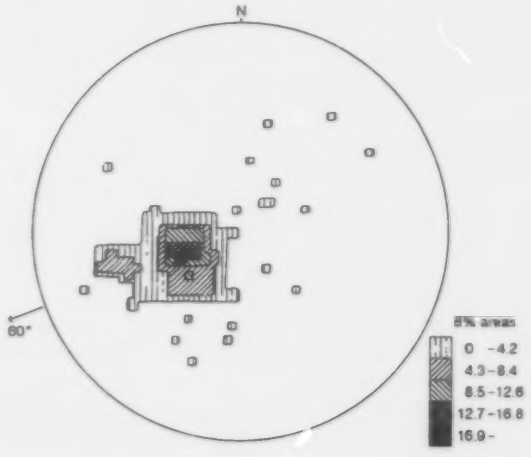

Figure 27. Contoured stereonet plot on lower hemisphere of clast elongation in felsic pyroclastic rocks from a total of 52 observations.

this fold occurs at the southwest corner of Patterson Island and in the area of better developed clast elongation. Consequently the clast elongation is interpreted to define the axis of this fold structure and extension in the "B" direction (Whitten 1966, p.268).

At several locations on the south coast of Patterson Island, Archean mafic dikes have been segmented and the intervening spaces filled with quartz. No necking of the dike segments was observed to suggest a boudinage type structure, thus the fracture was of a brittle nature. These quartz-filled spaces form an elongated body which defines a lineation. Too few readings were taken of this feature to make an interpretation but they appear to strike southwest and plunge generally concordant with clast elongation. The presence of the quartz-filled nodes suggest that deformation of the dikes occurred during the Archean concomitant with deformation and regional greenschist metamorphism and possibly prior to the late Archean folding event.

KINK BANDS

Kink bands are ubiquitous along the south coast of Patterson Island, becoming less developed and fewer in number to the north. They are absent from Mortimer and Delaute Islands. These features are much younger in age than, and have been superimposed on, the Archean penetrative schistosities. The kink bands may vary from 1 to 6 cm in width and commonly taper and die out in both directions (Photo 17). Only rarely can they be traced for distances exceeding 3 m. That portion of the kink band enclosed between the walls of the band is generally normal to, or at a high angle to, the trend of the band.

Measurements of axial planes of kink bands were plotted and contoured to determine dominant trends

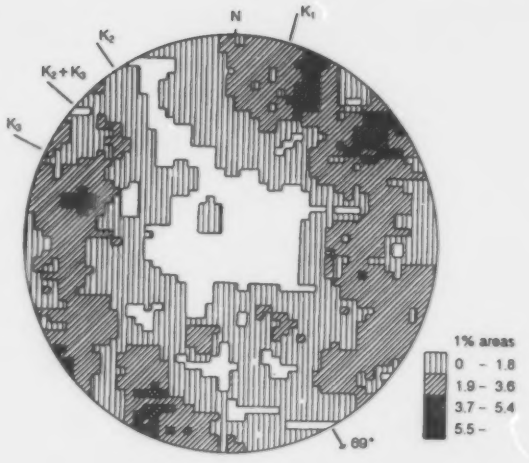

Figure 28. Contoured stereonet plot on lower hemisphere of axial planes of kink bands; K_1 north-northeast trending kink bands; K_2 northwest trending kink bands; K_3 north of west trending kink bands; $K_2 + K_3$ average of K_2 and K_3; line of intersection of K_1 and $K_2 + K_3$ plunges 69° south-southeast. Total of 179 observations.

(Figure 28). These indicate a N15°E trend (K_1) which dips 76° south and two other trends of N35°W (K_2) and N75°W (K_3) which are approximately vertically dipping. Since the K_2 and K_3 trends are likely the same feature they were averaged into a N50°W ($K_2 + K_3$) trend which is vertically dipping or perhaps dipping 80° south. There is no field evidence to support a separation of K_2 and K_3 into separate unrelated events.

K_1 occurs at a 60° angle to S_1, K_2 at 70° and K_3 at 30°. The distribution of trends suggests that the strongly anisotropic schistose rocks were deformed generating a conjugate set of kink bands. The compression and short-

Photo 17. Conjugate set of kink bands in sericite-chlorite schist, possibly a metamorphosed mafic tuff. Location P45.

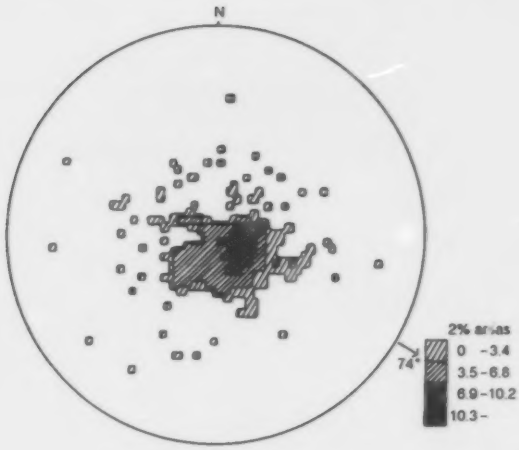

Figure 29. Contoured stereonet plot on lower hemisphere of kink band fold axes from 178 observations.

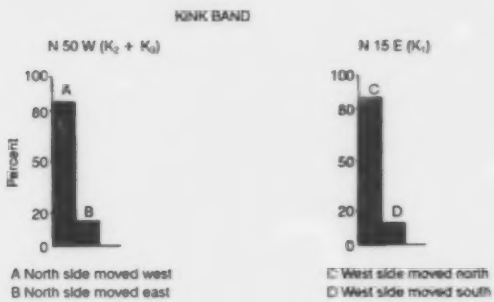

Figure 30. Histograms indicating relative movement on kink bands.

ening rotated the shear planes to a position such that slip could no longer occur in one of the shear directions and the third set subsequently developed. This model proposes essentially one period of movement. However, the trends may also represent a lock-slip mechanism of generation. The initial compressional force and shearing would generate a conjugate set of kink bands, pause, and then upon reactivation, shear only along one of the older sets necessitating the generation of one new set in another direction. This model proposes at least two periods of deformation even though undoubtedly related and occurring under the same stress system. Whether the kinking is one event or the result of a slip-lock mechanism cannot be positively determined.

A stereonet plot of the fold axis of the kink bands displays a high degree of scatter but establishes a general S60°E trend plunging at 74° (Figure 29).

To better evaluate the (K_2 + K_3) and K_1 trends, a histogram was prepared of the relative movements indicated by the bands (Figure 30). The broad scatter of data indicated by Figure 29 suggests that some kink band planes belonging to one trend were included in the other. Since there is no way of determining which trend a band is truly representative of other than its attitude, the observed 85% level of data indicating a particular direction of movement is considered very good. Adding the relative direction of suggested movement to the diagram in Figure 31 implies that compression was northeast to southwest and oriented parallel to S_1 and lithologic trends. In addition the indicated conjugate shear directions are 115° apart and not at 60° as is generally considered the angle of incipient shear (Billings 1954). Presumably this high angle represents rotation of the shear or kink bands concomitant with shortening in the northeast-southwest direction. Such shortening would result in extension in the northwest-southeast direction. Such a deformation or strain model was previously suggested for the Archean fold structures and faulting on Mortimer Island. The ease with which Archean struc-

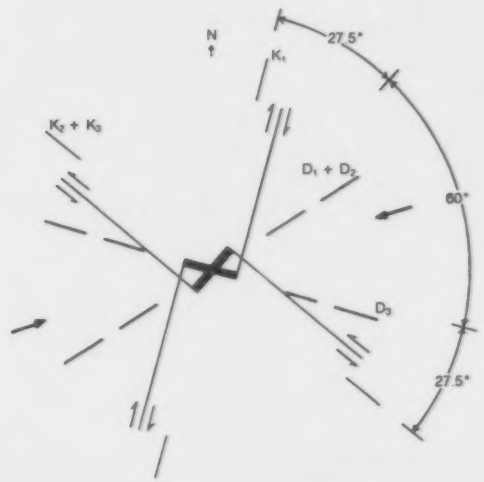

Figure 31. Schematic sketch indicating possible relationships between diabase dike emplacement and suggested zones of dilatancy as interpreted from kink band data.

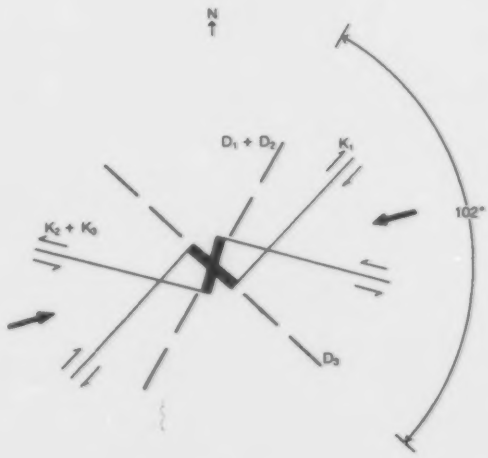

Figure 32. Schematic sketch indicating possible original shear directions and dike orientation along trends of indicated dilatancy.

tures can be explained using proposed Keweenawan stresses strongly suggests that Keweenawan tectonics followed Archean patterns.

Figure 31 is a diagrammatic sketch of a highly idealized kink. Field observations suggest that the schistose rocks connecting the flanks or walls of the band trend at right angles or at a very high angle to the flanks. A right angle relationship is indicated on the diagram (Figure 31). Onto this diagram were transferred the trend directions of the Keweenawan diabase dikes (*see* Figure 9). Dike trend D_3 parallels the kink direction of K_1 and the $(D_1 + D_2)$ trend generally lies parallel to the kink direction of $(K_2 + K_3)$. Since both $(D_1 + D_2)$ and $(K_2 + K_3)$ represent the averages of two trends on their respective diagrams, the presence of two similar trends on both diagrams in the same general position suggests a possible correlation. The ease with which trends of kink bands and trends of diabase dikes of Keweenawan age can be correlated supports the proposal that the kink bands are likely of Keweenawan age in development. The angle between $(D_1 + D_2)$ and D_3 is approximately 50° suggesting an apparent conjugate dike set. However, since the transverse directions in the kink bands have been rotated during compression along with the kink band itself, this appearance of a conjugate dike set is an apparent one only. Assuming that the kink bands were an original conjugate set oriented 60° apart, the dikes occupying the transverse directions of the kink bands would trend approximately N30°E and S58°E if unrotated. This would place the dikes at approximately 102° apart and eliminate the appearance of being a conjugate set (Figure 32). Therefore dike rotation is suggested to be on the order of 27°.

Halls (1979b, p.502) using paleomagnetic techniques also recognized the possibility that some diabase dikes were rotated. He suggested that this rotation was due to meteorite impact (Halls 1979b, p.562). Since the shock event is much more recent than the emplacement of the Keweenawan dikes it is difficult to explain why some dikes are rotated and others are not using the impact model. The author prefers a tectonic model in which intrusion, volcanism and deformation spanned an interval of Keweenawan time in which early emplaced dikes were rotated in later deformation. Using paleomagnetic data a dike rotation of up to 20° was proposed by Halls (1979b, p.570). The proposed dike rotation is comparable to that proposed by the author on the basis of dike geometry.

Some diabase dikes display extensive shearing within and along their contacts suggesting some adjustments while other dikes lack any evidence of significant deformation. Thus not all dikes are likely to have been rotated as is indicated by the paleomagnetic data of Halls (1979b). Presumably the dikes were not emplaced all at once but at various times during deformation and kink band formation, thus a highly variable degree of deformation of the dikes would be anticipated depending in part on their relative age of emplacement and in part on tectonic adjustment. It appears that the diabase dikes were emplaced in areas of dilatancy or low pressure defined by the normals to the direction of kink band development. Presumably this emplacement took place concomitant with Keweenawan volcanism. In addition the steep attitude of the kink band, and steep southeast to southwest plunge of their line of intersection and fold structures suggests that the compression is one of a predominantly horizontal nature. Consequently the mafic magmas probably arose steeply from the southeast and southwest.

STRUCTURAL TECTONIC SYNTHESIS

Because of the complex tectonic history of the islands a brief summary of the proposed structural-tectonic history is warranted. A brief chronological summary of events is given in Table 5.

The earliest recognizable or suggested tectonic feature is within the Archean. The coarse felsic pyroclastic

Table 5. Chronology of tectonic and structural events in the Slate Islands area.

POST-PENNSYLVANIAN

Diatremes were emplaced and generated shock metamorphic structures.

PENNSYLVANIAN (300 Ma)

Lamprophyre with carbonatitic affinity was emplaced on the southeast corner of Patterson Island. Earlier faults and/or shear zones may have undergone minor reactivation.

KEWEENAWAN 1000–1250 Ma

Kink band development, diabase dike emplacement into dilantant zones were concomitant with shearing and minor faulting, possibly accompanying shortening in a northeast-southwest direction and diabase dike rotation. Keweenawan mafic volcanism, kink band formation and diabase dike emplacement were all coeval; not all diabase dikes were rotated.

ANIMIKIE 1650–1900 Ma

Possibly some weak, post-Gunflint tectonism gave rise to broad open folds in the Gunflint, and the subsequent angular unconformity with overlying Keweenawan.

ARCHEAN (pre 2500 Ma)

Stage 2

The isoclinally folded supracrustal sequence was refolded into a steeply southwest plunging fold. Tectonic adjustments between Mortimer and Patterson Islands produced a complex minor fold pattern and possibly some major faulting or shearing. Extension in the northwest-southeast direction gave rise to or enhanced the Mortimer Island anticline and developed the pattern of shear zones found on the island. This late Archean tectonic event accentuated clast elongation in the southwestern portion of the island and generated a penetrative axial planar schistosity, (S_2). Quartz veins were rotated and locally shear folded. A possible second period of greenschist grade metamorphism, which localized gold mineralization in the zone of flexure, was associated with this second period of folding.

Stage 1

Concomitant with volcanism, the supracrustal rocks collapsed into an isoclinally folded northeast-trending sequence. A penetrative schistosity was generated parallel to original bedding, accompanied by initial clast elongation and development of fracture cleavage. These are vertical extensional features. Metamorphism coeval with above generated quartz veins which fill extensional or dilatancy structures. Controlling structure for a site of Archean volcanism is unknown. Isoclinal folding is assumed to be parallel to and identical to that described by Walker (1967) on the mainland opposite the islands.

rocks along the southeast side of Patterson Island suggest that this area was the site of Archean volcanism. Evidence is lacking as to what controlled the site of this volcanism such as rift, fracture, or continental margin. Collapse of the supracrustal rocks coincident with volcanism generated the penetrative S_1 schistosity, fracture cleavage, and incipient felsic pyroclastic clast elongation in the plane of S_5. These features likely reflect extension in the vertical direction. Coeval with this supracrustal collapse, greenschist grade of regional metamorphism occurred and the profuse development of quartz veins on Patterson and some of the smaller islands took place. These quartz veins generally fill extension or dilatancy features. This tectonic regime likely created a northeast-trending, isoclinally folded, supracrustal sequence similar to that described and mapped by Walker (1967) on the mainland and presumed by the author to extend to the offshore islands.

During the late Archean or at least prior to Animikie Gunflint deposition, the islands underwent a second period of significant tectonic adjustment of local extent. By analogy with the Keweenawan, this late Archean event likely reflects an essentially horizontal northeast-southwest compression and extension in the northwest-southeast direction. This deformation caused deformation and shear folding of the quartz veins in the Horace Cove area, generated the penetrative axial-planar S_2 schistosity, rotated the fracture cleavage in local areas, and modified the regional northeast lithologic trends locally to the northwest along the west side of Patterson Island. The compression-extension and related fault or shear adjustments between Mortimer and Patterson Islands may have generated the complex minor fold pattern between the two islands, and perhaps the suggested fold in the narrow neck connecting the east and west portions of Mortimer Island. The northwest-southeast extension accompanying the northeast-southwest compression generated or enhanced the anticlinal structures, the conjugate shears, the strike-slip shears, and low-angle, north-dipping shears found on Mortimer Island. This period of deformation accentuated clast elongation in the southwest part of the island suggesting or indicating a major fold structure superimposed on the earlier isoclinal folds and plunging steeply to the southwest. Clast elongation was in the "B" direction or parallel to the fold axis.

The area was largely quiescent during the Animikie and presumably the area was part of a basin. The Animikie Gunflint Formation was laid down in angular unconformity with the penetratively deformed Archean at this time. The general spatial outcrop distribution and dip of the bedding suggests that the Animikie underwent at least a minor deformational phase to account for the presence of some broad open folds and angular unconformity between itself and the Keweenawan volcanic rocks. It is conjectural but Animikie rocks are not known east of the Slate Islands. Sibley quartzite and possibly Rove argillite clasts are present in the McKellar Creek diatreme but not in the Deadhorse Creek diatreme several miles northeast of McKellar (Sage 1978a). Animikie rocks are not present around or within the Port Coldwell Alkalic Rock Complex (Sage unpublished data). Thus it would appear warranted to consider the possibility that the Big Bay–Ashburton Bay fault zone exerted control on Animikie sedimentation in this region of the Lake Superior Basin.

During the Keweenawan the Archean stress system was re-activated and during this tectonic period the kink bands were developed. This stress system may have been continuous or of a slip-lock nature. Dilatancy in extensional directions controlled diabase dike emplacements and thus Keweenawan mafic volcanism. Highly variable degrees of faulting and shearing of diabase dikes suggest that deformation may have occurred simultaneously with dike emplacement which undoubtedly took place over some interval of time. The dikes emplaced earliest would be the most deformed. An alternative interpretation is that this tectonic event is post-diabase and was selective in its location leaving some dikes highly sheared and others untouched.

The potassium-argon age of 300 Ma (D. Watkinson, Carleton University, Ottawa, personal communication, 1977) on the lamprophyre dike with carbonatite affinities located on the southeast coast of Patterson Island suggests an early to middle Paleozoic (Pennsylvanian) event. The amount of deformation associated with this event is unknown, but presumably earlier structures underwent re-activation at this time. Post-Ordovician kimberlite is present south of Lake Superior in proximity to the extrapolated extension of the Big Bay–Ashburton Bay Fault (Cannon and Mudrey 1981). Minor tectonic activity and alkalic magmatism occurred along the Big Bay–Ashburton Bay Fault during the middle Paleozoic.

Following the emplacement of the 300 Ma dike a diatreme event of unknown age took place. This event is likely a reflection of the fact that the islands occur on structures which appear to control the volatile-bearing alkalic rock–carbonatite intrusive events north of Lake Superior.

The emplacement of these breccia dikes may have been controlled, in part, along the west coast of Patterson Island by the Keweenawan–Archean unconformity. Along the east coast the control for diatreme emplacement is less obvious but likely related to north to northeast-trending fault zones lying east of Patterson Island. The author considers the diatreme emplacement event and the shock event the same.

In Figure 33 the relative directions of movement as determined in this study of the Slate Island structures have been superimposed on the regional fault pattern of Hinze et al. (1966) and agreement between movement directions and the fault pattern is indicated. The west side south movement on the Big Bay–Ashburton Bay fault is identical to the west side south movement found at Chipman Lake 140 km north of the Slate Islands and along the extrapolated northern extension of this fault zone. At Chipman Lake this fault cuts Archean rocks and has been the locus of carbonatite diking and fenitization (Sage et al. 1976). Horizontal displacement of the Archean stratigraphy at Chipman Lake is approxi-

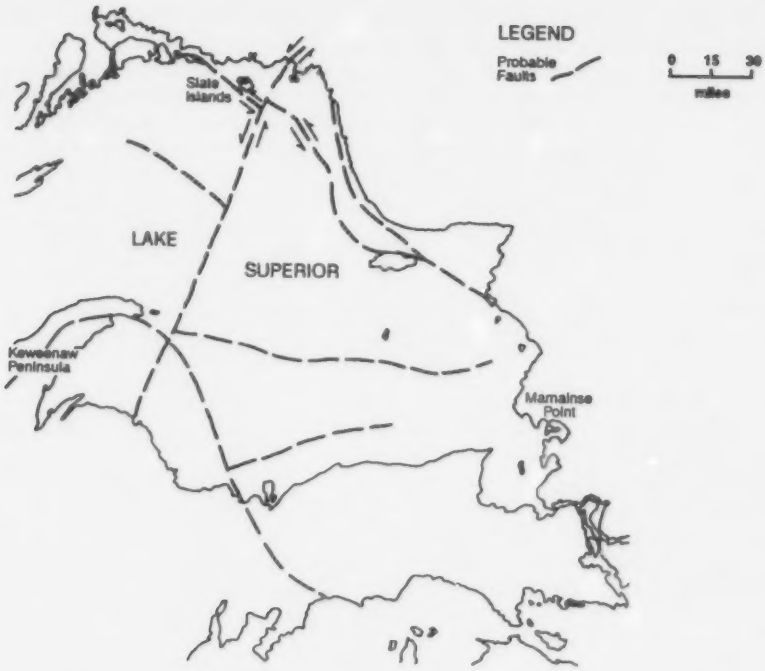

Figure 33. Faults of eastern Lake Superior (Hinze et al. 1966) with inferred directions of movement determined in this study.

mately 0.8 km (Sage et al. 1976). The presence of alkalic rocks along this fault indicates that the Big Bay–Ashburton Bay fault is a deep crustal fracture (Bailey 1974; Barker 1974).

GEOPHYSICAL EXPRESSION

Because of the structural complexity of the islands and regional setting a brief discussion of geophysical data pertinent to the geology of the island is warranted.

The first geophysical survey of the islands was an aeromagnetic and electromagnetic survey flown in 1960 with a northwest-southeast pattern at a 0.4 km (1/4 mile) spacing. The survey was flown by Canadian Aero Services Limited under contract to Kimberly–Clark Pulp and Paper Company Limited. The company at this time was actively investigating the islands for their gold and base metal potential and completed both surveys as part of their mineral evaluation program for the islands.

In April, 1962, Spartan Air Services Limited under contract to the Ontario and federal governments flew an aeromagnetic survey over the islands with a series of north-south flight lines at a line spacing of approximately 0.8 km (1/2 mile) (Map 2146G, ODM–GSC 1963). This survey indicated a rather complex aeromagnetic pattern over the island.

Neither the published aeromagnetic map 2146G (ODM–GSC 1963) nor the survey flown for Kimberly–Clark Pulp and Paper Company Limited completely covers the water surrounding the islands and between the islands and the mainland. The lack of airborne magnetic coverage of the submerged areas seriously hampers island to island correlation and the extrapolation of structural and lithologic data on the islands to that on the mainland. Of the two surveys, the one flown by Kimberly–Clark Pulp and Paper Company Limited is the most useful since it was flown at a closer line spacing than the government survey as well as being perpendicular to lithologic trends on most of the islands. Both the government and company surveys are of little value for correlation along the west coast of Patterson Island where lithologic units strike northwest at an acute angle to the flight lines of the government survey and parallel to the company survey.

The company survey clearly delineated a banded chert-magnetite horizon exposed on the east coast of Patterson Island and traced it approximately half way across the island where it apparently pinches out or develops a non-magnetic facies. The numerous weakly to moderately magnetic Archean intrusions and the abundant Keweenawan dikes have developed a confused and complex aeromagnetic pattern which cannot be interpreted without close ground control on the geology.

The electromagnetic survey failed to disclose any conductors and the in-phase and out-of-phase transformations occurred principally over the water-land contact. The abundance of sulphides in some horizons and particularly within some of the felsic to intermediate rocks along the southeast coast of Patterson Island would suggest the advisability of repeating this survey.

Aeromagnetic compilation maps (ODM–GSC 1965a, scale 1 inch to 4 miles; ODM–GSC 1970, scale 1 inch to 16 miles) give a better picture of the regional set-

ting of the islands. Both maps include some aeromagnetic data over the water between the islands and the mainland immediately to the north. Geologic data from the islands and the mainland between Terrace Bay and Marathon indicate however that lithologies and geologic structures on the mainland and the islands generally trend northeast and that the unsurveyed area between the islands and Ashburton Bay is the critical area for correlation purposes. This submerged region lacks airborne coverage needed for interpretive purposes even though direct evidence for tentative correlation with the mainland is indicated by the submerged ridge between the Slate Islands and Ashburton Bay, parallel to known structural trends.

To unravel the complex geology of the Slate Islands an understanding of the regional setting of the islands is relatively important since the islands represent the junction of several structural and tectonic trends in the Lake Superior Basin. The position of the Slate Islands on the margin of the Lake Superior syncline, which in part forms a portion of the Midcontinental Gravity High, makes an evaluation of its geophysical regional setting relatively important (Weber and Goodacre 1966). The Slate Islands themselves lie within a region of approximately -20 milligal gravity intensity, near the average value for the Lake Superior Basin.

Using aeromagnetic data that terminated just west of the Slate Islands, Wold and Ostenso (1966, p.92) concluded that in western Lake Superior: (1) a major fault north of Isle Royale (Isle Royale fault) trends north and east and is down thrown on the north side; (2) a major fault just south of St. Ignace Island near Rossport trends southwest to the east end of Isle Royale and possibly joins with the Isle Royale fault; and (3) the area northeast of Isle Royale is essentially a graben.

In eastern Lake Superior, Hinze et al. (1966, p.95) conducted similar aeromagnetic surveys and continued the structural interpretations of Wold and Ostenso (1966) eastward. The conclusions of Hinze et al. (1966, p.95, p.106) were: (1) a fault on the north side of Michipicoten Island (Michipicoten Island fault) continues southeast to Gargantua Point, parallel to the shoreline at a distance of 16 to 24 km and northwest towards Pic Bay, curving westward and passing immediately south of the Slate Islands on its way to the islands of Nipigon Bay; (2) the Keweenawan fault follows the Keweenawan Peninsula to the area just east of the peninsula where a possible cross fault striking from Ashburton Bay, Ontario, to Big Bay, Michigan, cuts the Keweenawan fault; and (3) the Big Bay–Ashburton Bay fault cuts the Isle Royale fault near Superior Shoal. The Big Bay–Ashburton Bay fault is represented by disruptions in the aeromagnetic pattern over the lake and is thought to be down thrown on the east side (Hinze et al. 1966, p.106). Aeromagnetic data also suggests that the Big Bay–Ashburton Bay fault offsets the Michipicoten Island fault immediately south of the Slate Islands (Hinze et al. 1966, p.107) and presumably the western extension of this fault would join with the fault of Wold and Ostenso (1966, p.92) just south of St. Ignace Island. Smith et al. (1966, p.181, 182) on the basis of seismic data have concluded that the depth to the Mohorovicic discontinuity increases from 20 km to 55 km or more, from western to eastern Lake Superior, with the deepest reading occurring over the northeast-trending Big Bay–Ashburton Bay structure. The Big Bay–Ashburton Bay fault is interpreted by Hinze et al. (1966, p.105) to pass immediately south of the Slate Islands where it intersects the Michipicoten Island fault. This fault zone would intersect the north coast of Lake Superior in proximity to the Port Coldwell Alkalic Complex, the west margin of which lies on Ashburton Bay (Ayres et al. 1970). Aeromagnetic maps 7088G and 7102G (ODM–GSC 1965a,b) and topographic features suggest that this linear structure continues inland until it reaches the Long Lac area, a distance of 140 km, and is characterized by alkalic magmatic events (Port Coldwell, Killala Lake, and Chipman Lake) (Ayres et al. 1970). From the aeromagnetic data and maps of Lilley (1964) and Hinze et al. (1966, p.103, 107) it appears that the Port Coldwell complex is an inverted cone, which is elliptical in plan view with a long axis generally parallel to the strike of the Big Bay–Ashburton Bay fault; in all probability the complex lies in this fault plane.

The work of Wold and Ostenso (1966) and particularly that of Hinze et al. (1966) indicates that the Slate Islands occur in proximity to the junction of two major fault systems, one of which continues onto the mainland and is characterized by alkalic magmatism. Such magmatism is considered characteristic of deep seated upper mantle or lower crustal events associated with major crustal rifting and low degrees of partial melting (Bailey 1974, p.148–150; Barker 1974, p.168–167; Gast 1968, p.1057).

Halls and West (1971, p.628) reported additional seismic studies of the Lake Superior Basin and concluded that (1) the Keweenawan volcanic rocks did not accumulate in a single basin occupying all of Lake Superior; in addition to the main basin between Isle Royale and Keweenawan Peninsula a smaller subsidiary basin occurs west of the Slate Islands; (2) the Michipicoten Island and Isle Royale faults previously discussed by Hinze et al. (1966) are down thrown on the north side; and (3) the contouring of Bayfield–Jacobsville Sandstone thickness supports the interpretation that the Isle Royale and Keweenawan faults terminated against a northeast-striking fault in eastern Lake Superior (Big Bay–Ashburton Bay fault). In 1972 Halls (p.1349) on the basis of seismic and aeromagnetic data postulated that a basement ridge in eastern Lake Superior extends from the Slate Islands to Superior Shoal over which the volcanic rocks and younger sedimentary rocks are relatively thin and which divided the lake into eastern and western parts. This interpretation was based on the following observations (Halls 1972, p.1361–1362): (1) reversely magnetized Osler volcanic rocks pinch out east of Copper Island towards the Slate Islands and are overlain by normally magnetized flows; (2) the Slate Island Archean rocks are the farthest known projection into Lake Superior; (3) linear magnetic minimums project southwest

from the Slate Islands to the Superior Shoal suggesting thinning or absence of the Keweenawan volcanic rocks; (4) seismic data suggests that the Bayfield–Jacobsville sandstones are thinner between the Slate Islands and Superior Shoal than they are farther west; and (5) samples collected from the Superior Shoal indicate the presence of Keweenawan volcanic rocks.

Additional support for a ridge crossing Lake Superior is provided by the bottom topography map of Hough (1958). The ridge indicated by Hough (1958), and postulated by Halls (1972), also follows the strike and location of the Big Bay–Ashburton Bay fault zone recognized by Hinze et al. (1966) and undoubtedly the ridge and proposed faulting are closely related.

White (1972, p.733) has postulated that a number of separate lava basins actually make up the Lake Superior synclinal structure and has interpreted the geologic and geophysical data to indicate that four of these basins terminate or pinch out along the trend of the indicated Big Bay–Ashburton Bay fault and ridge structure.

To the west of the Slate Islands in the Nipigon Strait area, Halls (1974b, p.1200) postulated that on the basis of paleomagnetic data an unconformity occurs in the Keweenawan volcanic rocks. Halls (1974a) completed a paleomagnetic study on the Keweenawan mafic volcanic rocks on the west coast of Patterson Island and correlated this sequence with the lower portion of the Osler Group further west along the north shore of Lake Superior. Halls (1975) on the basis of paleomagnetic data postulated that the Slate Islands Keweenawan rocks had undergone a shock event of Grenville age which he proposed was caused by meteoric impact.

In summation, geophysical, geologic, and topographic evidence indicate that the Slate Islands are situated at the junction of a number of features that are regional in scope. Geologic studies on these islands will undoubtedly provide a basis for interpretation of less accessible portions of the Lake Superior basin. The sections of this report dealing with alteration of both the Archean and Keweenawan rocks will be of aid to those planning geophysical studies in this region.

An airborne magnetic survey of the islands at a line spacing of 1000 yards and a height of 425 m was completed in 1979 and 1980, (Bengtson and Meyers 1981; Bengtson et al. 1981). Ground magnetometer, shipboard sonic profiling and reflection-refraction seismic surveys were completed in 1980 (Bengtson 1984). The study was started with the assumption that the islands are the product of meteor impact and alternate models were not entertained. Bengtson (1984, p.28) attributed the bathymetric pattern of the lake bottom to the shock event without interpreting the geological trends established on the islands and nearby mainland.

There has been relatively little erosion since Keweenawan time if the lateral injection of diabase across the penetrative schistosity can be taken to indicate a structural level of exposure where magmatic pressure is greater than lithostatic pressure. Earlier studies of deformation lamellae in quartz resulting from shock by Robertson and Grieve (1977) also indicated a relatively high level of structural exposure. The suggestion of significant uplift (Bengtson 1984) to form the islands needs confirmation. Bengtson (1984) proposed that fallback breccia, sandstone and ejecta were present even though none of these units exist on the islands nor were they recognized in seismic data.

Bengtson (1984, p.57, 58) indicated that the style of faulting near the islands is not known but assumed to be normal to be consistent with meteorite impact. The presence of a graben structure bounding the cryptoexplosion structure was also inferred since such grabens occur at other proposed impact sites but its presence at the Slate Islands was not established (Bengtson 1984, p.58).

In examining the proposed faults (Bengtson 1984), a pattern evolves which is consistent with the faulting proposed by the author or previously established by Walker (1967) and numerous geophysical studies of the Lake Superior basin (see Halls and West 1971; Hinze et al. 1966). Geophysical expression cannot be used by itself to distinguish an endogenous origin from an impact origin. The study needs expansion to be regional in scope, integrated with geology and then interpreted to establish if indeed the structures on and surrounding the islands are unique to the site. If the structures can be interpreted consistent with regional patterns an endogenous origin is suggested; if unique to the site of the Slate Islands an impact origin can be proposed. The geologic structure can at present be interpreted as consistent with regional structural trends and patterns.

Economic Geology

MINERAL EXPLORATION

In 1873 a mining claim of 102.7 acres was granted to Joseph Smith of Buffalo, New York, on the southeast coast of Patterson Island (files, Land Titles Section, Ontario Ministry of Natural Resources). A second mining claim consisting of 105.0 acres was later granted in 1878 to Edward Tobie of Buffalo, New York, which covered that portion of Mortimer Island now known as Lambton Cove. There is no record of prospecting work being done at this time and both claims were forfeited at a much later date (Land Titles Section, Ministry of Natural Resources).

In 1882, James Colebrook Patterson of Windsor, Ontario, paid $9,793 for the remaining 9,793 acres of the islands (excluding the above mining claims) (Land Titles Section, Ministry of Natural Resources; Land Registry Office, Thunder Bay).

Considerable prospecting work was being undertaken on the islands in 1899 (Bow 1899, p.95), and by 1901 mining had begun on the northwest coast of Patterson Island and had been in progress since 1899 (Bow 1901, p.87–88). The islands at this time remained in possession of J.C. Patterson who was then Lieutenant Governor of Manitoba (Bow 1901, p.87). Mining operations at this time consisted of driving two adits 120 m apart at lake level on the northwest corner of "South Slate Island" (Patterson Island) (Bow 1900, p.87). The south tunnel (No. 1) is 7.5 m in length and the north tunnel (No. 2) is 48 m in length, with a 1.5 m crosscut at its end. At the time of mapping, decayed remains of two buildings were present at the site.

In 1901, A.P. Coleman visited the islands to investigate reports that iron deposits were present on the island but he failed to find any occurrences of economic interest. Coleman (1901, p.137–138) did not mention the mining operations on the northwest coast and presumably these efforts had ceased by the time of this visit. Coleman (1901, p.137–138) published the first geologic report on islands.

In 1918, Parsons visited the islands to investigate reports of gold occurring on the islands. Parsons (1918, p.163) examined 10 sites of quartz vein development, some of which had gold mineralization and noted that persons unknown had driven an adit on the east side of "Copper Harbour" (Lambton Cove), presumably for copper. This adit occurs at lake level and is 18 m long and has a water filled winze of 3 m depth at its terminus. The author has been unable to locate any records concerning this early work at Lambton Cove and presumably reference to this cove as Copper Harbour is derived from this early prospecting effort. The driving of this adit at Lambton Cove probably took place sometime after Coleman's (1901) visit and before the visit of Parsons (1918). Parsons (1918) concluded from his investigation of the gold occurrences that the gold showing on the northwest corner of "St. Mary's Bay" (Horace Cove), known as the "F" vein, was the most promising.

From 1960 to 1963 Kimberly–Clark Pulp and Paper Company Limited (presently Kimberly–Clark of Canada Limited) conducted a mineral exploration program of the islands to test two gold showings (G.L. Puttock, Kimberly–Clark of Canada Limited, unpublished geophysical, geologic, and diamond drill data, personal communication, 1974). The main showing is on the northwest corner of "St. Mary's Bay" (Horace Cove) and the second occurs 240 m northeast of the St. Mary's Bay occurrence. The St. Mary's Bay occurrence is probably the same one that was described by Parsons (1918) as the "F" vein and is known as the St. Mary's Bay zone in Kimberly–Clark of Canada Limited records. The showing northeast of "St. Mary's Bay" is known as the Cosen's showing.

In 1960 the company contracted an aeromagnetic and electromagnetic survey of the island, at a 1/4 mile (0.4 km) line spacing (G.L. Puttock, personal communication, 1974). In 1961 and 1962 trenching, bulldozing, stripping, sampling and geologic mapping was done by the company over both the St. Mary's Bay zone and Cosen's showing. At St. Mary's Bay stripping by bulldozer to depths of 1.6 to 2.0 m covered an area of approximately 18 900 m^2; at Cosen's showing 240 m to the north, approximately 5350 m^2 of similar stripping was completed (G.E. Parsons, consulting geologist, personal communication, 1976). Members of the geological crew had difficulty finding this old work which had become filled and overgrown since early 1960s.

In 1963, Kimberly–Clark Pulp and Paper Company Limited formed the Slate Island Mining Company Limited (The Northern Miner, September 19, 1963). Kimberly–Clark Pulp and Paper Company Limited held a 50% interest, Junior Frood Mines Limited 25%, Upper Canada Mines Limited 12.5% and Cadamet Mines Limited 12.5% in this new company (Financial Post Survey of Mines, 1964, p.169). In 1963 this company completed 20 diamond drill holes, totalling an estimated 1974 m on the St. Mary's Bay zone (Puttock, personal communication, 1974). This work disclosed variable, but locally very high-grade, gold mineralization in quartz veins of short strike length and over narrow widths of 2 to 10 cm. The two gold showings tested by Kimberly–Clark were visited by members of this party but were found to be largely overgrown and not available for close examination. Mineral exploration of the islands ceased with the termination of the efforts of Kimberly–Clark.

In April 1973, finding the islands of no further use to them, the Kimberly–Clark of Canada Limited transferred its rights to the islands back to the Crown. Subsequently, in September 1973 the islands were removed from staking pending an evaluation of their potential (Central Records, Ontario Ministry of Natural Resources).

As of 1988, the islands were closed to staking pending further study. Those interested in working on the islands should contact the district office of the Ministry of Natural Resources in Terrace Bay to determine land status.

Closs (1975) completed a reconnaissance stream sediment geochemical survey of Mortimer and Patterson Islands. The -80 mesh fraction was analyzed for Cu, Pb, Zn, Co, Ni and Fe by atomic absorption spectrophotometry, for As by colormetric techniques and for Ag by emission spectrography. One anomalous value in zinc on Mortimer Island and two anomalous values in copper, one on Mortimer Island and one on Patterson Island, in excess of 1000 ppm were obtained and may warrant further investigation.

At the west end of Mortimer Island, a number of Zn values were in excess of 240 ppm (Closs 1975). Copper values greater than 400 ppm also occur more commonly on the west end of Mortimer Island (Closs 1975). Elevated Zn (greater than 240 ppm) and Cu (greater than 400 ppm) values are relatively limited in number and widely scattered on Patterson Island.

Closs (1975) indicated that the island physiography is not well suited for reconnaissance geochemistry and negative results do not preclude the presence of mineralization.

MINERAL DEPOSITS

ASBESTOS

The location of asbestos fibre on Francois Island suggests that the islands may have limited potential for an occurrence of this mineral commodity. The occurrence on the south side of Francois Island is in a pod of dark green, talcose, ultramafic rock 0.3 by 1 m and consists of irregular seams up to 1 cm in width. This mineral occurs in association with minor occurrence of ultramafic intrusive rocks which are most common on Delaute Island and Mortimer Island. These islands consequently are considered to offer the best possibility for the occurrence of an asbestos-bearing ultramafic body. Ground traversing by members of this field party has been sufficient to preclude the possibility of the presence of a large asbestos-bearing body but traversing has not been sufficiently detailed to rule out the possibility of a small ultramafic intrusion containing asbestos fibre of limited economic interest. The chances of locating such a deposit are not high.

COPPER

Chalcocite (copper) mineralization in narrow carbonate stringer veins (less than 0.3 m wide) within the Keweenawan volcanic flow rocks on the west side of Mortimer Island is too scattered and sparsely distributed to be of any economic interest. No evidence was observed of the presence of copper mineralization similar to that which occurs in similar rocks in Michigan and on the east coast of Lake Superior. The lack of significant mineralization and very localized occurrence of these rocks on the island means that there is little possibility of finding significant economic mineralization in the Keweenawan rocks.

IRON

Where examined, the Archean iron formation and Animikie iron formation are generally of narrow width (less than 18 m) and of low iron content. There is a general lack of significant aeromagnetic anomalies that would suggest the presence of large accumulations of iron formation. Consequently, the possibility of there being iron deposits of economic interest on the island is considered minimal.

SULPHIDES

The Archean felsic metavolcanics on Patterson Island and some of the smaller islands to the northeast are of the type recognized by exploration geologists as potentially favourable host rocks for massive sulphide mineralization. The airborne geophysical surveys of Kimberly-Clark Company Limited did not completely take into account the geologic structure of Patterson Island which has the best potential for sulphide mineralization of economic interest. The surveys are more effective over the eastern portions of the island where they were run normal to the stratigraphy but on the western portion the survey is of limited value for lithologic correlation or mineral search since they parallel the structure.

One well exposed pyrite occurrence occurs on the east side of Lambton Cove and has been tested by persons unknown. Grab samples of massive sulphides taken by the field party from the adit returned 0.11% copper and 0.28% zinc (analysis by Geoscience Laboratories, Ontario Geological Survey). In the cliff face northeast of the adit, massive and disseminated sulphides are present. This zone is 15 m wide with a 2.5 m band of argillite on the south flank containing the richest accumulation. The exposure is highly sheared and could not be traced to the top of the cliff face. The zone consists dominantly of brecciated mafic metavolcanics. The mineralization is generally erratic in distribution within the metavolcanics and the principal concentration is within the argillite. The argillite bedding appears to strike due east and dip vertically. The argillite soils the fingers and is presumed to be graphitic in nature. Within the argillite a zone 50 cm wide consists of flattened spheroids of pyrite. Some of these structures are zoned with finely crystalline cores and coarsely crystalline rims about 0.5 mm thick. The iron sulphide spheroids are up to 1.5 by 3.0 cm in size. The Lambton Cove sulphide occurrence is typical of the very minor sulphide bearing exposures on Mortimer Island.

A shear zone in felsic metavolcanics on the southeast coat of Patterson Island locally contains lenses of nearly massive pyrite, up to 75 cm thick. This zone strikes northeast, dips 60° south and has been traced for approximately 60 m along the coast. This material is deeply weathered and iron sulphate encrustations were identified as rozenite by X-ray diffraction (Geoscience

Laboratories, Ontario Geological Survey. A thirty element spectrographic analysis of sulphide samples from this zone disclosed no mineralization of economic interest.

Another occurrence of sulphide mineralization in association with felsic metavolcanics is present on the north side of Dupuis Island. A zone of nearly massive pyrite 40 cm wide, striking N27°E and dipping southeast, consists of spherical pyrite concretions. A thirty element spectrographic analysis of samples from this exposure indicated no mineralization of economic interest.

Massive pyritic float with traces of chalcopyrite was found on the beach of Patterson Island east of Cove Island.

GOLD

The potential for gold mineralization in the Archean rocks of the islands is very good. The islands and particularly Patterson Island contain abundant quartz veining which is known to host the gold mineralization found at "St. Mary's Bay" (Horace Cove) and at the Cosen's showing. Testing of these veins throughout the island for their gold content is warranted. The values encountered by Kimberly-Clark Pulp and Paper Company Limited on the St. Mary's Bay zone are of definite economic interest and this showing would undoubtedly be undergoing additional testing at the moment if the area was presently open to examination. While diamond drilling has been completed by Kimberly-Clark on the St. Mary's Bay zone, the Cosen's showing to the northeast which also contains some high grade gold mineralization has never been tested at depth.

As shown on Figures 34 and 35 (Chart A, back pocket) the gold-bearing, quartz-carbonate veins of St. Mary's Bay zone and Cosen's showing display a strong southwest strike. Since the host rocks of the veins are folded into a northwest-trending sequence, these veins are actually approximately normal to stratigraphy as was observed in several places along the east coast of Patterson Island. Some evidence for shear folding of the quartz veins is indicated at the St. Mary's Bay zone (Figure 34) by the irregular sawtooth pattern of some of the veins (Photo 18). The vein orientation normal to stratigraphy, schistosity (S_1), pyroclastic clast elongation, and parallel to the fracture cleavage are generally consistent with emplacement in dilatancy fractures derived by vertical extension (Schwerdtner 1974) which is likely correlative with the earliest period of deformation on the island.

The quartz veins of the St. Mary's Bay zone and Cosen's showing occupy the inflection point in the major fold structure on Patterson Island, presumably a position of dilatancy.

Nichols (1963, p.20) was the first to recognize the fact that gold-bearing quartz veins on Patterson Island occurred in the nose of a fold. These mineralized veins were interpreted to occupy shear and tension fractures (Nichols 1963, p.37).

Based on samples and descriptions by G.E. Parsons (consulting geologist, personal communication, 1974), under whose direction the exploratory work for Kimberly-Clark Pulp and Paper Company Limited was completed in the St. Mary's Bay area, gold mineralization occurs in three ways. These are (1) in association with pyrite within the quartz-carbonate veins; (2) as flakes and thin sheets along the flanks of the quartz-carbonate veins; and (3) as thin sheets or flakes along schistosity

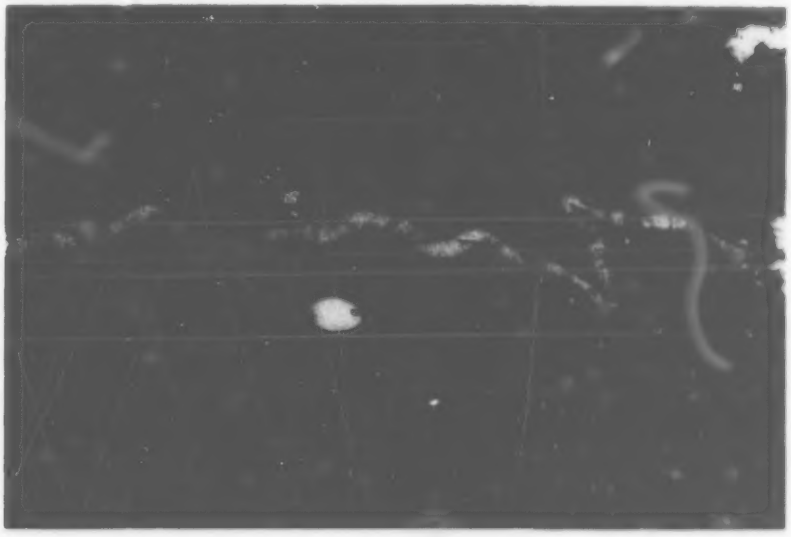

Photo 18. Shear-folded quartz veins in sericite schist at St. Mary's Bay zone. Highest gold values appear to be in the more complexly folded quartz veins. Location P46.

planes of the rocks enclosing the quartz-carbonate veins.

During routine mapping of the islands, quartz vein attitudes were routinely measured and grab samples were taken. The assay results generally returned nil to insignificant values except for the St. Mary's Bay zone, where assays of 0.5 ounces per ton over widths of 2–3 cm were obtained. Figures 34 and 35 show assays and plans of veins for the St. Mary's Bay zone and the Cosen's showing (from maps prepared by G.E. Parsons for Kimberly-Clark Pulp and Paper Company Limited).

The quartz veins vary from tabular, lensoid, clearly defined veins to irregular anastomosing structures with no clearly discernible attitude. An average of 98 clearly definable veins gave an average width of 10.7 cm and a length of 5.5 m. Reddish-brown, coarse-grained carbonate is a ubiquitous, accessory to dominant mineral and pyrite is common to abundant. Rarely, black needle-like crystals of tourmaline were noted.

A contoured stereonet plot of 167 quartz vein attitudes (Figure 36) indicates a rather broad spread of attitudes with one and possibly two maxima. One maxima (Q_2), the strongest, defines a N70°E vein set dipping approximately 60° southeast. The second maxima (Q_1) defines a N35°E vertically dipping vein set. The intersection of these two trends would define a lineation striking S30°W plunging about 14° southwest.

The diagram was plotted using all the vein attitudes measured on the island. In fact the island comprises several domains and the veins for each domain should be plotted and interpreted separately. On the southeast corner of Patterson Island the veins occur approximately normal to the strike of the schistosity. On the southwest coast the veins parallel the schistosity but are roughly normal to lithologic trends. On the east and southeast coast the veins are commonly straight but are convolutely shear folded and perhaps partly rotated in the area of St. Mary's Bay zone. The veins appear to be of Archean age and were developed prior to the Archean folding.

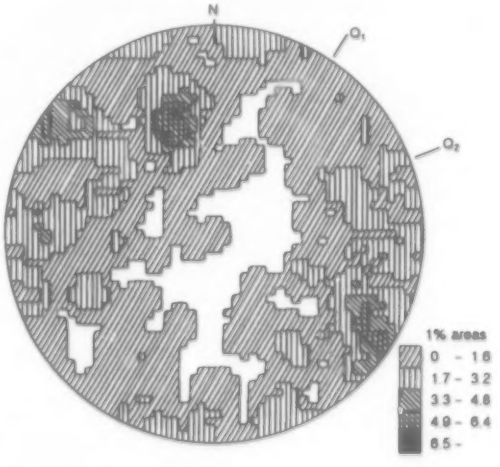

Figure 36. Contoured stereonet plot on lower hemisphere of quartz vein attitudes from 167 data points.

Quartz veins are more common in the more altered rocks of Patterson and Leadman Islands than in the less altered rocks of Mortimer Island. This spatial association with highly altered rocks, lack of magmatic source, and location in positions of extension or dilatancy (normal to original schistosity S_1) is consistent with the metamorphic vein-forming model proposed by Boyle (1961) for the Yellowknife area.

Nichols (1963) described the gold-bearing veins in St. Mary's Bay zone as consisting of quartz, pyrite and siderite with a northeast strike. The veins are commonly less than 100 feet long and vary from 1 to 5 inches in width (Nichols 1963). Little alteration was reported to be present (Nichols 1963). The gold mineralization was related to an unexposed granite intrusion by Nichols (1963) but there is no evidence of such an intrusion nearby or at depth.

RECOMMENDATIONS TO THE PROSPECTOR

There is potential for an economically feasible gold deposit on the island and previous work on the gold showings has not adequately tested their viability. In addition, both the St. Mary's Bay zone and Cosen's showing appear to occur at the approximate location of the axial plane or inflection in strike of the lithologic units from a southwest to a northwest trend. Prospecting along the trend of this inflection may be warranted.

The search for base metals on the island has been minimal and former airborne geophysical surveys were inadequate to test base metal potential. In light of the occurrence of rock types on the islands known to be favourable for base metal mineralization, adequate geophysical and surface evaluation followed by diamond drill testing of any anomalous areas is warranted. As concepts and techniques change, testing of the islands may be periodically justified.

The land status of the islands should be confirmed through the district office of the Ministry of Natural Resources.

Appendix A—Petrographic Descriptions, Chemical Analyses and Normative Compositions of Lithologic Units of the Slate Islands.

Table A-1. Petrographic and field descriptions of whole-rock samples from Slate Islands.

Ref. No. 1
Sample No. SL2-39C

Mafic metavolcanics.

Field Description. Massive to pillowed, variolitic, with variolites up to 7 mm in diameter. Map unit 1h.

Petrographic Description. Euhedral plagioclase crystals (calcic) are partially saussuritized and set in a groundmass of chlorite and extremely saussuritized plagioclase. The rock is slightly variolitic. Minor stringers of carbonate and amphibole are present.

Ref. No. 2
Sample No. SL3-23

Mafic metavolcanics.

Field Description. Massive, fine grained, greenish weathering. Map unit 1a.

Petrographic Description. Fine grained clinopyroxene and laths of plagioclase exhibit a former diabasic texture. Minor amounts of anhedral quartz, chlorite (penninite) and opaques are present.

Ref. No. 3
Sample No. SL10-15

Mafic metavolcanics.

Field Description. Very fine grained. Sample taken from core of pillow structure in mafic metavolcanics. Map unit 1a.

Petrographic Description. Fine grained, subhedral clinopyroxenes and laths of calcic plagioclase, are mottled with carbonate. Locally the plagioclase shows a variolitic texture. Minor stringers of carbonate are present.

Ref. No. 4
Sample No. SL10-45

Plagioclase-carbonate rock.

Field Description. Very fine grained, aphanitic, tan to buff clast in dark green chloritic matrix. Probably a mafic flow breccia. Sample from a clast. Map unit 1d.

Petrographic Description. The carbonate pseudomorphs the clinopyroxene (relict cleavage traces), mottles the plagioclase, and also occurs as stringers. Minor amounts of quartz, opaques, and chlorite are present.

Ref. No. 5
Sample No. SL10-82

Mafic metavolcanics.

Field Description. Very fine grained, aphanitic, pillowed. Sample taken from core of pillow structure. Map unit 1c.

Petrographic Description. Plagioclase occurs in variolitic structures and is extremely saussuritized (cloudy appearance). Minor anhedral quartz is present. Some veinlets and stringers of penninite are associated with carbonate.

Ref. No. 6
Sample No. SL18-5B

Mafic metavolcanics.

Field Description. Very fine grained, aphanitic, medium green weathering. Sample from core of pillow structure. Map unit 1c.

Petrographic Description. Carbonate pseudomorphs the larger plagioclase crystals and also occurs as stringers and finer-grained, irregular masses. Fine grained plagioclase and some chlorite are present. Minor anhedral quartz is fractured. Minor anhedral grains of chlorite are penninite.

Ref. No. 7
Sample No. SL18-7

Mafic metavolcanics.

Field Description. Very fine grained, medium green weathering, aphanitic or pillowed. Sample from core of pillow structure. Map unit 1c.

Petrographic Description. Abundant fine- to medium-grained laths of saussuritized plagioclase and some chlorite are the main minerals. Interstitial clinopyroxene (augite?) occurs mostly as subhedral crystals. Minor stringers of carbonate are present.

Ref. No. 8
Sample No. SL18-22

Mafic metavolcanics.

Field Description. Very fine grained, medium green weathering, pillowed. Sample from core of pillow structure. Map unit 1c.

Petrographic Description. Laths of plagioclase and chlorite with a slight development of a variolitic texture. Locally plagioclase is pseudomorphed by carbonate. Carbonate also occurs as scattered, irregular masses and a few stringers. Abundant clinopyroxene is prismatic and anhedral. Some anhedral quartz is present.

Ref. No. 9
Sample No. SL18-40

Dunite.

Field Description. Reddish brown weathering, fine grained, massive, possibly a flow rock (?). Map unit 4g.

Petrographic Description. Euhedral to subhedral olivine crystals are slightly serpentinized and highly altered by carbonate. The carbonate forms the boundary between the crystals and mottles the crystals irregularly and along fractures.

Ref. No. 10
Sample No. SL12-159A

Mafic metavolcanics.

Field Description. Very fine grained, reddish to medium green weathering, massive to schistose. Rock is homogeneous and contains dark green chlorite spots up to 4 mm in diameter. Map unit 1b.

Petrographic Description. Plagioclase occurs as euhedral porphyroblasts with inclusions of a more calcic plagioclase. Groundmass consists of numerous fine grained laths of saussuritized plagioclase with minor, interstitial quartz and clinopyroxene all in a slight alignment hinting at schistosity. Abundant carbonate partially pseudomorphs and mottles the plagioclase. Occasional medium-grained laths and crystal aggregates of chlorite are present.

Ref. No. 11
Sample No. SL20-30A

Mafic metavolcanics.

Field Description. Very fine grained, aphanitic, highly schistose, light to medium green. Sample taken from the core of a pillow structure. Map unit 1c.

Petrographic Description. Very fine grained plagioclase and chlorite (minor opaques) exhibit a schistose texture. One large phenocryst of clinopyroxene shows polysynthetic twinning. Some irregular patches of carbonate.

Ref. No. 12
Sample No. SL20-37

Mafic metavolcanics.

Field Description. Greenish black weathering, schistose, from amygdaloidal layer. Sample is homogeneous chlorite schist with scattered, < 0.5 mm, plagioclase feldspar phenocrysts. Map unit 1e.

Petrographic Description. The rock is mostly chlorite with small grains of quartz and plagioclase. The chlorite exhibits a schistose texture. Carbonate occurs as numerous, irregular masses (some possible pseudomorphs of plagioclase).

Ref. No. 13
Sample No. SL20-40B

Mafic metavolcanics.

Field Description. Grey green weathering, amygdaloidal, schistose. Sample was taken from a homogeneous, non-amygdaloidal area. The amygdaloids in the area range from up to 2 cm in maximum dimension. Map unit 1e.

Petrographic Description. Schistose chlorite with very fine grained quartz and plagioclase. Roughly elongate masses of carbonate parallel the schistosity.

Ref. No. 14
Sample No. SL20-53

Mafic metavolcanics.

Field Description. Schistose, amygdaloidal. Some 2-3 mm dark green chlorite spots suggest former phenocrysts. Amygdaloids are up to 1 cm. Sample was taken from non-amygdaloidal area of outcrop within homogeneous chlorite schist. Map unit 1e.

Petrographic Description. The rock consists mostly of saussuritized laths of plagioclase somewhat aligned and locally showing a former diabasic texture. Minor carbonate mottles the plagioclase. Laths and crystal aggregates of chlorite define a schistosity. Minor interstitial quartz is present.

Ref. No. 15
Sample No. SL28-5B

Chloritic Schist.

Field Description. Very fine grained. Sample from the core of a pillow structure within the only pillowed unit found on Patterson Island. Map unit 1c.

Petrographic Description. Chloritic schist with abundant saussurite alteration; minor interstitial quartz is present.

Ref. No. 16
Sample No. SL28-7B

Chlorite-carbonate schist.

Field Description. Very fine grained aphanitic. Sample from the core of a pillow structure within the only pillowed unit on Patterson Island. Map unit 1c.

Petrographic Description. The rock consists of aphanitic chlorite and carbonate, and is schistose. Minor porphyroblasts of chlorite (up to 5 mm) are present.

Ref. No. 17
Sample No. SL4-12

Felsic metavolcanics.

Field Description. Buff to pink weathering, massive to weakly schistose, homogeneous. Map unit 2e.

Petrographic Description. The rock is siliceous and consists of fine grained quartz, feldspar and carbonate. It is texturally homogeneous. Plagioclase phenocrysts are extremely altered (carbonatization and saussuritization). Irregular porphyroblasts of carbonate are bordered with a cloudy, opaque mineral (possibly limonitic staining) which also occurs as veinlets. Minor euhedral chlorite is present.

Ref. No. 18
Sample No. SL6-24G

Plagioclase-sericite schist.

Field Description. Light brown weathering, weakly schistose, very fine grained, very homogeneous. Map unit 2a.

Petrographic Description. The rock is fine grained, schistose and consists of quartz and sericite with minor carbonate as elongate masses. The schistose matrix is bent around altered phenocrysts of plagioclase. Opaque phenocrysts are euhedral and have pressure shadows of quartz.

Ref. No. 19
Sample No. SL12-111A

Quartz, carbonate, sericite schist.

Field Description. Very fine grained, reddish-brown weathering, homogeneous and contains dark green chlorite spots up to 4 mm in diameter. Map unit 2e.

Petrographic Description. The rock consists of quartz, carbonate (with ferruginous staining) and sericite with a poorly developed schistosity. Carbonate occurs as numerous, irregular masses and replaces minor clinopyroxene. Plagioclase occurs as subhedral phenocrysts and also is fine grained in the matrix.

Ref. No. 20
Sample No. SL12-199C

Sericite schist.

Field Description. Pinkish brown, homogeneous, probably a flow rock. Map unit 2d.

Petrographic Description. The rock is a sericitic schist with numerous subhedral carbonate porphyroblasts (0.2 mm), minor veinlets and blebs of quartz, carbonate.

Ref. No. 21
Sample No. SL14-96C

Carbonate-sericite schist.

Field Description. Schistose, pink to buff weathering, with feldspar phenocrysts up to 1 mm. Rock is probably a volcanic flow rock. Map unit 2f.

Petrographic Description. Well foliated schist with abundant oblate porphyroblasts of carbonate (0.5 mm in size).

Ref. No. 22
Sample No. SL20-6C

Chlorite-plagioclase-sericite schist.

Field Description. Very fine grained aphanitic, felsic volcanic flow breccia with clasts up to 68 by 52 cm. Rock weathers reddish brown to buff. Sample taken from a clast characteristic of the unit. Map unit 2a.

Petrographic Description. The rock is a sericite schist with euhedral phenocrysts of plagioclase with abundant sericite alteration, and numerous subhedral porphyroblasts of chlorite, carbonate, quartz and opaques. The few opaque porphyroblasts have pressure shadows.

Ref. No. 23
Sample No. SL24-17B

Sericite schist.

Field Description. Very fine grained, red rhyolite clast from rhyolite flow breccia. Map unit 2b.

Petrographic Description. The rock is a well foliated sericite schist with phenocrysts of plagioclase and irregular masses of carbonate.

Ref. No. 24
Sample No. SL24-42K

Plagioclase-sericite schist.

Field Description. Red weathering, very fine grained aphanitic, rhyolite clast from rhyolite flow breccia. Map unit 2a.

Petrographic Description. The rock consists of fine grained quartz, sericite, chlorite, and feldspar; it is slightly schistose with numerous,

euhedral phenocrysts of plagioclase. One crystal shows zoning. Feldspars are altered to sericite and saussurite. Minor patches of carbonate are present.

Ref. No. 25
Sample No. SL24-42M

Plagioclase-sericite schist.

Field Description. Light apple green weathering, very fine grained aphanitic, rhyolite clast from rhyolite flow breccia. Map unit 2a.

Petrographic Description. The matrix (85% of the rock) consists of fine grained quartz, sericite and feldspar; it is schistose and contains numerous phenocrysts of sericitized plagioclase (with evidence of zoning), and minor anhedral quartz and carbonate. Some of the plagioclase exhibits vague pressure shadows. Some euhedral chlorite (penninite) is present.

Ref. No. 26
Sample No. SL28-9B

Sericite schist.

Field Description. Light grey green weathering, dacite flow breccia. Sample is a very fine grained clast taken from the flow unit and represents dominant clast type. Map unit 2a.

Petrographic Description. The rock consists of fine grained chlorite and sericite with minor, irregularly shaped masses (fine grained) of carbonate. Numerous capillary veins of cloudy carbonate cut through the section.

Ref. No. 27
Sample No. SL28-10C

Plagioclase-carbonate-chlorite-sericite schist.

Field Description. Reddish brown to brown weathering, volcanic flow breccia with clasts up to 3 by 2 m. Sample is very fine grained aphanitic clast representative of the dominant clast type within this unit. Map unit 2b.

Petrographic Description. The rock consists of schistose chlorite and sericite with minor fine grained quartz and plagioclase wrapped around the few phenocrysts of altered plagioclase. Abundant carbonate occurs as irregular patches, fine to medium grained, and also as cloudy veinlets. Numerous aphanitic opaques with Fe oxide staining are scattered throughout.

Ref. No. 28
Sample No. SL28-12

Quartz-feldspar-chlorite-sericite schist.

Field Description. Reddish brown weathering, flow banded dacite to rhyolite, very fine grained. Map unit 2e.

Petrographic Description. The rock is schistose and consists of quartz, feldspar, chlorite and sericite (with radiating structures); it is clouded with abundant iron oxide staining. A few veinlets of carbonate, the odd porphyroblast of carbonate and phenocryst of plagioclase are present.

Ref. No. 29
Sample No. SL28-23

Sericite schist.

Field Description. Light grey green weathering, flow breccia. Sample is a very fine grained clast taken from the flow unit and represents dominant clast type. Map unit 2a.

Petrographic Description. The rock consists of aphanitic, schistose sericite and chlorite with some quartz and feldspar. It contains scattered, subhedral porphyroblasts of carbonate with Fe oxide staining. Minor, extremely saussuritized phenocrysts of plagioclase and a few stringers of quartz are present.

Ref. No. 30
Sample No. SL29-36

Quartz-plagioclase-sericitic schist.

Field Description. Fine grained, homogeneous, schistose quartz-feldspar porphyry. Rock weathers a reddish brown. Map unit 5d.

Petrographic Description. Schistosity is developed in an aphanitic matrix of sericite, quartz and feldspar. Sericitized phenocrysts of plagioclase are abundant. Smaller phenocrysts of chlorite and quartz are minor. Some carbonate alteration mottles the section.

Ref. No. 31
Sample No. SL30-31C

Quartz-feldspar-sericite schist.

Field Description. Fine grained, grey white weathering, aphanitic, homogeneous, schistose rhyolite. Map unit 2d.

Petrographic Description. The matrix is slightly schistose and consists of quartz, sericite and feldspar. Matrix is bent around phenocrysts of saussuritized plagioclase (subhedral). Irregular patches of carbonate are associated with the plagioclase.

Ref. No. 32
Sample No. SL31-49

Feldspar-sericite schist.

Field Description. Light green, very fine grained, homogeneous, aphanitic, moderately schistose rhyolite. Map unit 2e.

Petrographic Description. Well developed sericite, quartz feldspar schist is bent around numerous saussuritized plagioclase phenocrysts. There are vague indications of original zoning in some of the phenocrysts. Irregular masses of carbonate are associated with some of the plagioclase (central area of phenocryst).

Ref. No. 33
Sample No. SL6-16A

Plagioclase-chlorite-quartz-sericite schist.

Field Description. Feldspar porphyry clasts are set in a chloritic matrix. The rock is a flow breccia and weathers reddish brown. Phenocrysts ar up to 5 mm in length. Sample from clast. Map unit 1j.

Petrographic Description. The rock has a quartz chlorite sericite schistose matrix. Elongate clots of schistose sericite and quartz are bordered with chlorite. Porphyroblasts of carbonate are also bordered with chlorite. Irregular, aphanitic patches of carbonate are abundant throughout the matrix, as are phenocrysts of sericitized plagioclase with some pressure shadows. The matrix bends around the plagioclase.

Ref. No. 34
Sample No. SL6-34

Feldspar porphyry.

Field Description. Feldspar porphyry flow rock weathers mottled pink and green; pink feldspar phenocrysts are up to 5 mm across. Dark chlorite clots up to 4-5 mm along schistosity planes suggest former mafic phenocrysts. Rock may be a flow breccia and sample is taken from the center of one of the clasts. Map unit 1j.

Petrographic Description. Coarse-grained phenocrysts of extremely saussuritized and carbonatized plagioclase give the rock a dark cloudy appearance. Numerous elongate masses (fine grained) of carbonate parallel schistosity of matrix. The matrix is also extremely altered and composed of quartz, feldspar, chlorite and minor sericite.

Ref. No. 35
Sample No. SL6-58B

Plagioclase-sericite schist.

Field Description. Schistose homogeneous feldspar porphyry weathers to a reddish brown and has phenocrysts up to 1 cm across. The unit is either a thick flow centre or sill. Map unit 2g.

Petrographic Description. The matrix consists of schistose sericite, chlorite, quartz, feldspar and minor carbonate. The matrix is bent around coarse-grained phenocrysts of sericitized plagioclase with pres-

sure shadows. Large porphyroblasts of carbonate always have associated chlorite along the edge or scattered throughout. The odd phenocryst of polygonized quartz is present.

Ref. No. 36
Sample No. SL14-144X

Chlorite-feldspar-sericite schist.

Field Description. Mottled bright red with green streaks, schistose, feldspar porphyry. Phenocrysts are up to 5 mm in length and bright orange-red in colour. Sample from non-amygdaloidal outcrop in a sequence of amygdaloidal feldspar porphyry flow rocks. Chlorite mottled with dark green spots on a lighter background, suggests the former presence of a mafic phenocryst. Feldspar composes an estimated 60% of the rock. Map unit 2g.

Petrographic Description. Numerous, extremely sericitized, plagioclase phenocrysts (up to 3 mm in size) are set in a schistose matrix of sericite, quartz and feldspar. Porphyroblasts and laths of chlorite are mottled with patches of carbonate. Specks of carbonate are scattered throughout matrix. Fe oxide staining of carbonate gives the section a buff colour.

Ref. No. 37
Sample No. SL114-146X

Chlorite-plagioclase-sericite schist.

Field Description. Mottled bright red to orange-red and green, schistose, nonamygdaloidal, feldspar porphyry in a section of amygdaloidal and pyroclastic feldspar-porphyry flow rocks. Bright orange red feldspar phenocrysts up to 3 mm are set in a mottled light and dark green chlorite schist which suggests the former presence of mafic phenocrysts. Feldspar composes an estimated 60% of the rock. Map unit 2g.

Petrographic Description. Numerous phenocrysts of plagioclase (65%) are extensively altered with carbonate and sericite and set in schistose matrix of chlorite, sericite, quartz and feldspar. Minor aggregates of chlorite (up to 2 mm in size) are mottled with carbonate. Minor Fe oxide staining.

Ref. No. 38
Sample No. SL20-24B

Chlorite-plagioclase-sericite schist.

Field Description. Feldspar porphyry flow breccia with clasts up to 38 by 34 cm. Some clasts have well developed reaction rims. The rock weathers mottled orange to pinkish green and has pink feldspar phenocrysts up to 6 mm in length and dark chloritic spots up to 5 mm, possibly after hornblende. Sample taken from centre of largest, most homogeneous clast. Map unit 2h.

Petrographic Description. Phenocryst of plagioclase and chlorite are extensively sericitized (only minor in chlorite). Some of the plagioclase is pseudomorphed with carbonate. Matrix consists of sericite and an aphanitic, cloudy carbonate along with some chlorite. Texture is very schistose. The matrix also contains a few grains of plagioclase and some quartz.

Ref. No. 39
Sample No. SL14-126

Quartz diorite.

Field Description. Massive, fine to medium grained, grey-green weathering. Map unit 4a.

Petrographic Description. The rock consists of euhedral, intensely saussuritized plagioclase, with clinopyroxene slightly altered to chlorite plus some crystal aggregates of chlorite. Interstitial quartz is present.

Ref. No. 40
Sample No. SL20-90B

Diorite.

Field Description. Fine to medium grained, equigranular, massive. Map unit 4a.

Petrographic Description. The rock consists mostly of extremely saussuritized plagioclase with some porphyroblasts of chlorite with specs of carbonate. A few aggregates of relict clinopyroxene are altered to very fine grained amphibole (actinolite?) and chlorite.

Ref. No. 41
Sample No. SL29-71B

Quartz diorite.

Field Description. Light grey-brown weathering, medium-grained, massive. Map unit 4a.

Petrographic Description. The rock consists of intensely saussuritized plagioclase and calcic clinopyroxene, with very minor chlorite and sericite. Interstitial quartz in some places displays deformation lamellae.

Ref. No. 42
Sample No. SL24-5B

Quartz-feldspar-sericite-chlorite schist.

Field Description. Schistose, greenish grey weathering, quartz feldspar porphyry with quartz phenocryst up to 4 mm (1%) and feldspar phenocrysts up to 5 mm long (5-10%). Map unit 5d.

Petrographic Description. Plagioclase (sericitized) and quartz phenocrysts are set in a schistose matrix of quartz, feldspar, chlorite, sericite and carbonate which bends around them. Minor opaques and some crystal aggregates of chlorite are present. Minor small carbonate porphyroblasts.

Ref. No. 43
Sample No. SL24-12

Quartz-feldspar-sericite schist.

Field Description. Red weathering, schistose, homogeneous, quartz-feldspar porphyry with quartz phenocrysts up to 4 mm and bright red feldspar phenocrysts up to 5 mm in sericite schist matrix. Map unit 5d.

Petrographic Description. Quartz, carbonate and sericitized plagioclase porphyroblasts are set in a matrix (80%) of quartz, sericite, feldspar and carbonate with a well developed schistosity. Minor chlorite is present. A capillary vein of carbonate cuts the section.

Ref. No. 44
Sample No. SL24-48

Plagioclase-sericite schist.

Field Description. Bright red weathering feldspar phenocrysts are set in a dark green, chloritic matrix. Rock is a feldspar porphyry with feldspar crystals up to 5 mm in length, and very homogeneous. Map unit 5f.

Petrographic Description. Numerous sheared and sericitized plagioclase (An_{40}) phenocrysts are associated with large patches of carbonate. Very schistose matrix consists of quartz, feldspar, sericite, and carbonate.

Ref. No. 45
Sample No. SL24-50

Plagioclase-sericite schist.

Field Description. Greenish pink weathering, schistose, homogeneous feldspar porphyry with feldspar phenocrysts up to 5 mm in length. Map unit 5f.

Petrographic Description. Sericitized plagioclase (An_{40}) phenocrysts are sheared and have well developed pressure shadows. The matrix is highly schistose quartz, feldspar, sericite, chlorite and carbonate.

Ref. No. 46
Sample No. SL24-55

Plagioclase-sericite schist.

Field Description. Buff weathering, schistose, homogeneous feldspar porphyry with bright orange feldspar phenocrysts up to 3 mm in length. Map unit 5f.

Petrographic Description. Sericitized and carbonatized phenocrysts of plagioclase and minor porphyroblasts of quartz and chlorite with carbonate are set in a schistose matrix of sericite, chlorite, quartz, feldspar and carbonate.

Ref. No. 47
Sample No. SL24-68B

Plagioclase sericite, schist.

Field Description. Buff weathering, feldspar porphyry with red feldspar phenocrysts up to 4 mm long. Rock is schistose and homogeneous. Map unit 5f.

Petrographic Description. Fractured and sericitized plagioclase phenocrysts have some poorly developed pressure shadows. Irregularly shaped patches and stringers of carbonate are scattered throughout the schistose matrix which consists of quartz, feldspar, sericite and minor chlorite.

Ref. No. 48
Sample No. SL24-71A

Plagioclase sericite schist.

Field Description. Light green weathering, schistose, homogeneous feldspar porphyry with red feldspar phenocrysts up to 5 mm in length. Map unit 5f.

Petrographic Description. Sericitized phenocrysts of plagioclase are fractured. The fractures are filled with sericite and quartz and most of the phenocrysts have well developed pressure shadows of sericite and quartz. Scattered patches of carbonate are present. The aphanitic schistose matrix consists of quartz, feldspar, sericite and minor chlorite.

Ref. No. 49
Sample No. SL24-95

Plagioclase quartz carbonate sericite schist.

Field Description. Bright red weathering, schistose, homogeneous, quartz-feldspar porphyry with quartz phenocrysts up to 2-3 mm (1-5%) and red feldspar phenocrysts up to 2-3 mm (10-15%). Map unit 5d.

Petrographic Description. Plagioclase (An_{33}) phenocrysts are extremely sericitized and minor oblate quartz phenocrysts show a re-absorption relict texture. Granular carbonate is abundant throughout with phenocrysts and matrix. Schistose matrix consists of quartz, feldspar, sericite and chlorite.

Ref. No. 50
Sample No. SL6-30P1

Plagioclase-quartz-carbonate-sericite schist.

Field Description. Pink weathering, massive quartz feldspar porphyry with quartz phenocrysts up to 3 mm (3-4%) and feldspar phenocrysts up to 5 mm (15-20%). Map unit 5a.

Petrographic Description. Plagioclase (An_{38}) phenocrysts are extremely sericitized and oblate quartz phenocrysts show relict reabsorption. The schistose matrix (85%) consists of quartz, feldspar, sericite and abundant, irregular, patchy, fine grained carbonate.

Ref. No. 51
Sample No. SL24-84

Quartz-feldspar porphyry.

Field Description. Bright red weathering, massive quartz-feldspar porphyry with quartz phenocrysts up to 3 mm (10%) and feldspar phenocrysts up to 3 mm (40%). Map unit 5a.

Petrographic Description. Fractured sericitized, subhedral plagioclase and oblate strained quartz phenocrysts are set in a polygonized matrix of quartz, feldspar, carbonate, sericite and limonite. Chlorite occcurs as masses of crystal aggregates.

Ref. No. 52
Sample No. KW-1

Diabase.

Field Description. Fine- to medium-grained, massive diabase sill. Sample collected from the centre of the sill. Columnar jointing is well developed. Map unit 8c.

Petrographic Description. The rock consists of fresh labradorite plagioclase with slightly altered, interstitial augite. The augite with poikilitic laths of plagioclase shows well developed ophitic texture.

Ref. No. 53
Sample No. KW-2

Keweenawan mafic flow.

Field Description. Fine to medium-grained, massive mafic flow. Sample collected from the centre of the flow. Map unit 7a.

Petrographic Description. The rock consists of mottled, medium-grained laths of plagioclase, interstitial carbonate and phenocrysts of intensely altered clinopyroxene. Clinopyroxene exhibits reaction rims of carbonate with minor amphibole which mantles the central portion of the pyroxene grains. Interstitial opaques, Fe oxide staining, and devitrified glass are also present.

Ref. No. 54
Sample No. KW-3

Keweenawan mafic flow.

Field Description. Fine- to medium-grained, massive mafic flow. Sample collected from the centre of the flow. Map unit 7a.

Petrographic Description. Laths of plagioclase occur with extremely altered, interstitial clinopyroxene and irregular patches of devitrified glass. Opaques and Fe oxide staining are abundant. Carbonate occurs as small patches and cloudy mottlings replacing primary mineralogy.

Ref. No. 55
Sample No. KW-4

Keweenawan mafic flow.

Field Description. Fine- to medium-grained massive mafic flow. Sample collected from the centre of the flow. Map unit 7a.

Petrographic Description. Medium-grained, extremely altered plagioclase and augite have a former diabasic texture. Opaques, Fe oxides and altered glass occur interstitially. Carbonate mottles the plagioclase.

Ref. No. 56
Sample No. KW-5

Keweenawan mafic flow.

Field Description. Fine- to medium-grained, massive mafic flow. Sample collected from the centre of flow. Map unit 7a.

Petrographic Description. Laths of plagioclase occur with large anhedral crystals of clinopyroxene exhibiting reaction rims of fibrous amphibole and chlorite. In some cases the pyroxene is intensely altered. Minor specks of carbonate, numerous needles of opaques with some Fe oxide staining and a few areas of devitrified glass are present.

Ref. No. 57
Sample No. KW-6

Keweenawan mafic flow.

Field Description. Fine to medium-grained, massive mafic flow. Sample collected from the centre of the flow. Map unit 7a.

Petrographic Description. Laths of plagioclase and granular clinopyroxene form a diabasic texture, riddled with needles of opaques. The clinopyroxene is intensely altered to a fibrous amphibole, chlorite and sometimes pseudomorphed with carbonate. Patches of devitrified glass also occur.

Ref. No. 58
Sample No. SL22-9B

Diabase.

Field Description. Brown weathering, massive, fine to medium grained. Map unit 8b.

Petrographic Description. Laths of plagioclase and augite form a well developed diabasic texture. The augite is slightly altered to chlorite and minor amphibole. The plagioclase is slightly sericitized. Opaques are distributed randomly.

Ref. No. 59
Sample No. SL28-11

Olivine diabase.

Field Description. Medium grained, equigranular, massive. Rock weathers brown to reddish brown. Map unit 8b.

Petrographic Description. Euhedral crystals of olivine (30%) are set in coarser-grained augite and calcic plagioclase. Accessory minerals are chlorite, biotite and opaques.

Ref. No. 60
Sample No. SL14-224D

Diabase.

Field Description. Fine to medium grained, equigranular, massive. Map unit 8b.

Petrographic Description. The rock is medium grained with laths of sericitized plagioclase and abundant anhedral clinopyroxene altered to fibrous amphibole and chlorite. Opaques are distributed randomly.

Ref. No. 61
Sample No. SL29-22

Olivine diabase.

Field Description. Fine to medium grained, massive. Map unit 8b.

Petrographic Description. Altered subhedral olivine (serpentine, iddingsite?) (5%) occurs with abundant augite and laths of labradorite plagioclase. Minor opaques are present.

Ref. No. 62
Sample No. SL29-49

Diabase.

Field Description. Fine grained, massive, columnar jointed. Map unit 8b.

Petrographic Description. The rock is fine grained with laths of labradorite and subhedral augite partially altered to chlorite and minor amphibole. Accessories are biotite and opaques.

Ref. No. 63
Sample No. LIGHTHOUSE

Diabase.

Field Description. Fine to medium grained, equigranular, massive. Map unit 8b.

Petrographic Description. The rock is fine to medium grained. Augite is granular and interstitial to laths of plagioclase (labradorite). Augite shows some alteration to fibrous amphibole and chlorite. Abundant magnetite is also interstitial to the plagioclase. Biotite is an accessory.

Ref. No. 64
Sample No. SL24-90

Porphyritic diabase.

Field Description. Porphyritic with two types of phenocrysts up to 1 cm in diameter. One is light apple green pyroxene and forms less than 1% of the rock. The other is an altered phenocryst presumably after pyroxene and forms 2-3% of the rock. Dike has well developed columnar jointing. Map unit 8f.

Petrographic Description. The rock is medium grained with laths of labradorite plagioclase and interstitial clinopyroxene. Phenocrysts are clinopyroxenes and possibly olivine which is extensively altered to serpentine. Minor opaques, chlorite and biotite are present.

Ref. No. 65
Sample No. SL14-206

Porphyritic diabase.

Field Description. Porphyritic dike with apple green pyroxene phenocrysts (1%) and dark green carbonatized phenocrysts of pyroxene(?) (2-4%). Dike is otherwise massive. Map unit 8f.

Petrographic Description. The rock is medium grained with laths of plagioclase and interstitial, granular clinopyroxene. Large phenocrysts are extensively serpentinized olivine; numerous, smaller, circular phenocrysts are probably clinopyroxene now completely altered to fibrous amphibole and chlorite with carbonate in the central portion of the phenocryst. Carbonate forms capillary veinlets. Scattered opaques, chlorite, and biotite are present.

Ref. No. 66
Sample No. SL14-79A

Diabase.

Field Description. Fine grained, massive, dark red weathering. Map unit 8h.

Petrographic Description. The rock is medium grained with laths of labradorite and subhedral crystals of augite locally showing an ophitic texture with respect to the plagioclase. Scattered opaques (3%), dark green biotite, euhedral apatite and abundant Fe oxide staining are present.

Ref. No. 67
Sample No. SL20-25

Diabase.

Field Description. Fine grained, massive, dark red weathering. Map unit 8h.

Petrographic Description. The rock is medium grained. Laths of labradorite have limonitic staining. Clinopyroxene is interstitial and opaques, chlorite and biotite are present. Apatite is an accessory.

Ref. No. 68
Sample No. SL24-13

Olivine-phlogopite lamprophyre.

Field Description. Greenish grey to bluish grey weathering, massive, porphyritic with a fine grained, micaceous matrix. Olivine phenocrysts up to 1 cm compose up to 1% of the rock. Map unit 9a.

Petrographic Description. The rock consists mostly of medium to coarse grained crystal aggregates of garnet and large subhedral crystals of phlogopite both with chlorite alteration. In some cases, chlorite appears to have pseudomorphed the garnet. Carbonate, euhedral apatite, magnetite and perovskite also occur in lesser amounts. Minor serpentine after olivine. No fresh olivine present. The texture is fine to medium grained, massive, inequigranular-porphyritic-seriate, hypidiomorphic.

Ref. No. 69
Sample No. SL24-21

Olivine-phlogopite lamprophyre.

Field Description. Blue-grey weathering, fine grained, magnetic. Olivine phenocrysts up to 1 cm compose up to 1% of the rock. Map unit 9a.

Petrographic Description. The rock is medium grained and contains partially serpentinized and chloritized phenocrysts of olivine, accompanied by a mineral assemblage of phlogopite, chlorite, apatite, magnetite, and perovskite, all of which are mottled with carbonate replacement. The texture is fine to medium grained, massive, inequigranular-porphyritic-seriate, hypidiomorphic.

Ref. No. 70
Sample No. SL24-54

Olivine-phlogopite lamprophyre.

Field Description. Bluish grey weathering, with olivine phenocrysts up to 5 mm in a fine-grain mica matrix. Rock is massive but has a fragmental appearance on weathered surface. Clasts are autoliths and of same composition as matrix. Map unit 9a.

Petrographic Description. The rock is medium grained and contains anhedral phlogopite with chloritic alteration. Large crystals of phlogopite are poikilitic with inclusions of magnetite, perovskite, and apatite. Abundant carbonate mottles this mineral assemblage. The texture is fine to medium grained, massive, inequigranular-porphyritic-seriate, hypidiomorphic.

Table A–2. Major element analyses (weight percent) of whole-rock samples from Slate Islands.

	Archean Mafic to Intermediate Metavolcanic Rocks. (Map Unit 1).					
Ref. No.	**1**	**2**	**3**	**4**	**5**	**6**
SiO_2	48.90	48.90	52.20	48.70	52.20	49.30
Al_2O_3	15.90	15.50	13.80	15.50	14.80	17.20
Fe_2O_3	1.13	1.89	0.48	1.17	0.44	0.18
FeO	9.24	9.73	8.93	5.92	8.35	5.60
MgO	6.59	7.35	6.14	7.77	6.09	4.95
CaO	10.70	8.49	10.80	7.79	10.50	7.52
Na_2O	0.92	2.10	2.08	2.24	3.02	2.13
K_2O	0.22	0.24	0.12	0.39	0.17	1.18
H_2O^+	3.54	3.40	1.94	4.41	2.09	4.12
H_2O^-	0.30	0.63	0.43	0.67	0.43	1.05
CO_2	0.41	0.15	1.08	3.32	0.70	5.60
TiO_2	1.15	1.13	1.38	0.74	1.12	0.79
P_2O_5	0.10	0.07	0.10	0.03	0.12	0.03
S	0.02	0.03	0.03	0.62	0.03	0.05
MnO	0.25	0.21	0.24	0.18	0.22	0.26
Total	99.4	99.8	99.8	99.4	100.3	100.0
S.G.	2.97	2.94	2.93	3.25	2.90	2.67

	Archean Mafic to Intermediate Metavolcanic and Intrusive Rocks. (Map Units 1 And 4).					
Ref. No.	**7**	**8**	**9**	**10**	**11**	**12**
SiO_2	53.40	50.50	37.50	59.00	55.70	46.60
Al_2O_3	14.80	14.60	3.74	14.00	16.50	12.80
Fe_2O_3	1.04	0.45	2.05	2.11	1.17	1.05
FeO	6.65	8.35	6.65	3.41	5.92	8.59
MgO	5.75	5.30	21.80	3.40	2.86	7.38
CaO	7.70	10.40	11.00	4.00	4.80	9.52
Na_2O	3.37	3.69	0.19	4.26	2.05	1.59
K_2O	0.31	0.19	0.02	0.77	1.93	0.10
H_2O^+	3.63	2.42	4.74	1.20	3.26	4.77
H_2O^-	0.94	0.67	0.74	0.53	0.60	0.53
CO_2	1.20	2.20	11.50	5.00	3.28	5.72
TiO_2	1.19	1.30	0.26	0.59	1.14	1.12
P_2O_5	0.13	0.13	0.01	0.19	0.08	0.04
S	0.12	0.03	0.07	0.01	0.17	0.01
MnO	0.18	0.24	0.15	0.08	0.23	0.20
Total	100.3	100.5	100.4	98.6	99.7	100.0
S.G.	2.80	2.85	2.78	2.73	2.77	2.73

Notes: For sample descriptions, see Table A–1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.
Chemical classification according to Irvine & Baragar (1971).

Ref. No.	Sample No.	Chemical Classification	Ref. No.	Sample No.	Chemical Classification
1	SL2–39C	Tholeiitic basalt	7	SL18–7	Calc-alkalic basalt
2	SL3–23	Tholeiitic basalt	8	SL18–22	Calc-alkalic basalt
3	SL10–15	Tholeiitic basalt	9	SL18–40	Ultramafic
4	SL10–45	Calc-alkalic basalt	10	SL12–159A	Calc-alkalic andesite
5	SL10–82	Tholeiitic basalt	11	SL20–30A	Calc-alkalic basalt
6	SL18–5B	Calc-alkalic basalt	12	SL20–37	Tholeiitic basalt

Table A–2. Continued.

	Archean Mafic to Intermediate Metavolcanic and Intrusive Rocks. (Map Units 1 And 4).						
Ref. No.	**13**	**14**	**15**	**16**	**39**	**40**	**41**
SiO_2	48.50	57.40	58.10	48.50	48.50	48.40	49.60
Al_2O_3	12.80	15.60	14.30	13.40	16.20	15.50	14.60
Fe_2O_3	1.63	1.04	1.07	1.11	1.76	2.76	2.83
FeO	8.52	5.14	3.64	9.08	6.33	7.05	6.00
MgO	9.07	5.87	2.61	4.80	7.13	8.58	8.90
CaO	7.10	3.11	7.77	8.57	14.00	7.73	11.70
Na_2O	1.73	3.77	3.86	1.32	1.83	2.35	1.82
K_2O	0.10	0.87	0.70	0.87	0.12	0.17	0.12
H_2O^+	4.77	3.32	1.98	3.96	0.89	3.61	2.25
H_2O^-	0.57	0.54	0.27	0.71	0.57	0.62	0.60
CO_2	4.26	1.36	4.10	6.50	1.50	1.26	0.55
TiO_2	0.90	0.79	1.13	1.03	0.54	1.04	0.59
P_2O_5	0.06	0.11	0.21	0.09	0.02	0.06	0.06
S	0.01	0.02	0.02	0.02	0.08	0.11	0.06
MnO	0.13	0.15	0.15	0.29	0.16	0.17	0.15
Total	100.2	99.1	99.9	100.2	99.6	99.4	99.8
S.G.	2.71	2.66	2.71	2.77	2.99	2.85	2.98

	Archean Intermediate to Felsic Metavolcanic Rocks (Map Unit 2).							
Ref. No.	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
SiO_2	70.20	67.00	59.30	61.00	52.80	53.90	68.80	69.60
Al_2O_3	14.90	15.10	13.60	16.70	16.90	17.30	15.50	15.80
Fe_2O_3	0.54	1.47	2.35	1.43	0.81	0.13	0.35	0.11
FeO	0.81	1.78	2.92	1.95	4.38	3.40	0.65	0.65
MgO	0.24	0.74	2.90	1.10	1.84	2.61	0.33	0.43
CaO	3.65	3.00	3.80	4.10	6.84	5.92	4.60	2.82
Na_2O	3.40	4.64	3.80	2.88	2.59	6.25	3.15	6.09
K_2O	1.76	1.64	1.21	2.70	1.71	0.92	1.20	0.99
H_2O^+	0.78	0.87	1.57	0.99	1.27	1.13	1.16	0.80
H_2O^-	0.36	0.46	0.53	0.61	0.82	0.47	0.46	0.38
CO_2	2.10	1.40	6.20	4.90	9.55	7.00	3.04	1.40
TiO_2	0.42	0.62	0.59	0.69	0.79	0.72	0.44	0.42
P_2O_5	0.12	0.13	0.18	0.21	0.16	0.17	0.09	0.08
S	0.12	0.02	0.02	0.02	0.03	0.04	0.01	0.01
MnO	0.04	0.08	0.06	0.08	0.12	0.20	0.09	0.04
Total	99.4	99.0	99.0	99.4	100.6	100.2	99.9	99.6
S.G.	2.71	2.71	2.75	2.73	2.80	2.72	2.69	2.68

Notes: For sample descriptions, see Table A–1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.
Chemical classification according to Irvine & Baragar (1971).

Ref. No.	Sample No.	Chemical Classification	Ref. No.	Sample No.	Chemical Classification
13	SL20–40B	Tholeiitic basalt	18	SL6–24G	Calc-alkalic dacite
14	SL20–53	Calc-alkalic andesite	19	SL12–111A	Calc-alkalic andesite
15	SL28–5B	Calc-alkalic andesite	20	SL12–199C	Calc-alkalic andesite
16	SL28–7B	Tholeiitic basalt	21	SL14–96C	Calc-alkalic basalt
39	SL14–126	Tholeiitic basalt	22	SL20–6C	Mugearite
40	SL20–90B	Tholeiitic basalt	23	SL24–17B	Calc-alkalic dacite
41	SL29–77B	Tholeiitic basalt	24	SL24–42K	Calc-alkalic dacite
17	SL4–12	Calc-alkalic dacite			

Table A–2. Continued.

	Archean Intermediate to Felsic Metavolcanic and Intrusive Rocks (Map Units 2 and 5).							
Ref. No.	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**
SiO_2	71.60	71.70	69.80	69.30	73.40	62.90	71.80	70.80
Al_2O_3	15.40	12.60	14.60	15.30	13.80	14.60	15.30	17.20
Fe_2O_3	0.32	0.05	0.23	0.54	0.25	1.74	0.10	0.37
FeO	0.73	0.65	0.97	2.27	0.81	2.03	0.49	0.73
MgO	0.44	0.30	0.61	1.12	0.46	2.50	0.50	0.61
CaO	3.40	4.81	4.22	1.52	2.37	4.10	2.00	2.19
Na_2O	5.28	5.23	3.83	3.83	3.34	3.88	6.79	3.80
K_2O	0.94	0.34	0.94	2.77	1.35	1.16	0.63	1.61
H_2O^+	0.45	0.00	0.53	0.98	0.80	1.71	0.32	0.35
H_2O^-	0.35	0.51	0.72	0.76	0.60	0.60	0.45	0.55
CO_2	0.55	2.80	3.00	0.95	1.70	2.94	0.98	1.30
TiO_2	0.48	0.33	0.35	0.47	0.37	0.29	0.29	0.32
P_2O_5	0.09	0.07	0.07	0.09	0.05	0.10	0.08	0.07
S	0.01	0.02	0.04	0.02	0.02	0.05	0.02	0.09
MnO	0.03	0.04	0.07	0.05	0.07	0.05	0.01	0.02
Total	100.1	99.4	100.0	100.0	99.4	98.6	99.8	100.0
S.G.	2.69	2.64	2.64	2.62	2.68	2.66	2.63	2.68

	Archean Felsic to Intermediate Metavolcanic and Intrusive Rocks (Map Units 1, 2 and 5).							
Ref. No.	**33**	**34**	**35**	**36**	**37**	**38**	**42**	**43**
SiO_2	64.20	55.60	59.20	64.00	54.20	56.70	60.90	66.70
Al_2O_3	15.50	17.10	18.60	15.5	18.10	13.80	15.20	15.10
Fe_2O_3	0.12	1.86	0.37	0.80	1.49	0.89	1.21	0.56
FeO	3.00	3.97	3.81	1.97	3.87	2.60	3.73	0.89
MgO	1.67	2.50	1.95	2.34	3.65	3.88	2.01	0.49
CaO	4.75	8.92	4.24	3.47	3.50	8.94	5.08	4.51
Na_2O	3.37	2.86	3.24	5.82	3.67	3.07	2.51	3.77
K_2O	1.23	0.87	1.57	1.30	1.88	2.05	1.71	1.59
H_2O^+	1.69	2.14	3.48	1.32	2.75	2.27	2.20	0.98
H_2O^-	0.49	0.35	0.43	0.48	0.62	0.46	0.42	0.37
CO_2	2.46	2.08	2.66	2.22	4.47	4.72	2.44	3.36
TiO_2	0.53	0.84	0.64	0.37	0.62	0.65	1.84	0.94
P_2O_5	0.09	0.15	0.12	0.11	0.09	0.14	0.48	0.10
S	0.03	0.02	0.04	0.03	0.01	0.13	0.03	0.03
MnO	0.07	0.12	0.08	0.06	0.08	0.08	0.11	0.05
Total	99.2	99.4	100.4	99.8	99.0	100.4	99.9	99.4
S.G.	2.71	2.82	2.72	2.62	2.72	2.66	2.71	2.67

Notes: For sample descriptions, see Table A–1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.
Chemical classification according to Irvine & Baragar (1971).

Ref. No.	Sample No.	Chemical Classification	Ref. No.	Sample No.	Chemical Classification
25	SL24–42M	Calc-alkalic dacite	33	SL6–16A	Calc-alkalic andesite
26	SL28–9B	Calc-alkalic dacite	34	SL6–34	Calc-alkalic basalt
27	SL28–10C	Calc-alkalic dacite	35	SL6–58B	Calc-alkalic andesite
28	SL28–12	Calc-alkalic dacite	36	SL14–114X	Calc-alkalic dacite
29	SL28–23	Calc-alkalic dacite	37	SL14–146X	Calc-alkalic andesite
30	SL29–36	Calc-alkalic andesite	38	SL20–24B	Calc-alkalic andesite
31	SL30–31C	Calc-alkalic rhyolite	42	SL24–5B	Calc-alkalic andesite
32	SL31–49	Calc-alkalic dacite	43	SL24–12	Calc-alkalic dacite

Table A–2. Continued.

	Archean Felsic to Intermediate Intrusive Rocks (Map Unit 5).							
Ref. No.	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**
SiO_2	61.80	64.30	67.30	63.50	64.70	62.60	59.90	63.70
Al_2O_3	16.40	15.30	15.10	17.20	16.10	15.10	14.60	15.20
Fe_2O_3	1.32	0.74	1.89	1.43	1.19	0.72	1.35	1.25
FeO	1.69	2.02	0.97	1.55	1.46	2.11	1.78	1.30
MgO	1.52	2.10	1.29	1.68	1.47	1.90	2.35	2.00
CaO	4.59	4.41	2.85	3.32	3.56	4.09	5.31	4.41
Na_2O	3.50	4.42	4.29	4.15	5.20	3.83	3.34	6.69
K_2O	2.34	1.52	1.95	1.71	1.11	1.95	2.02	0.58
H_2O^+	0.94	1.97	1.03	1.09	0.95	0.74	0.78	0.49
H_2O^-	0.45	0.28	0.32	0.42	0.29	0.34	0.35	0.31
CO_2	3.20	1.16	1.44	2.16	2.50	5.50	6.80	3.20
TiO_2	0.48	0.39	0.37	0.40	0.35	0.38	0.46	0.39
P_2O_5	0.11	0.13	0.12	0.09	0.14	0.14	0.13	0.12
S	0.01	0.01	0.01	0.01	0.01	0.02	0.04	0.02
MnO	0.06	0.07	0.06	0.05	0.06	0.08	0.08	0.07
Total	98.4	98.8	99.0	98.8	99.1	99.5	99.3	99.7
S.G.	2.70	2.69	2.62	2.69	2.69	2.71	2.72	2.67

	Proterozoic Mafic Flow Rocks and Diabase Intrusion (Map Units 7 and 8).					
Ref. No.	**52**	**53**	**54**	**55**	**56**	**57**
SiO_2	47.50	46.20	45.60	46.60	47.70	45.10
Al_2O_3	15.80	10.70	10.20	9.41	11.20	14.10
Fe_2O_3	4.14	9.68	7.48	7.92	5.18	6.34
FeO	7.70	3.89	5.60	5.02	7.13	5.27
MgO	5.39	6.22	7.48	7.92	8.21	5.27
CaO	10.50	10.20	10.80	10.20	9.74	10.30
Na_2O	2.16	1.78	1.81	1.59	1.48	1.86
K_2O	0.46	0.48	0.29	0.41	0.12	0.29
H_2O^+	1.92	3.08	2.58	2.41	3.06	3.50
H_2O^-	1.32	2.00	2.01	2.00	2.29	1.40
CO_2	1.35	4.48	3.32	3.20	1.50	4.60
TiO_2	1.52	2.26	2.36	2.10	2.34	2.50
P_2O_5	0.14	0.18	0.18	0.16	0.22	0.23
S	0.02	0.02	0.01	0.02	0.02	0.02
MnO	0.24	0.18	0.18	0.18	0.19	0.22
Total	100.2	101.4	99.9	99.1	100.4	101.0
S.G.	2.84	2.74	2.78	2.78	2.77	2.73

Notes: For sample descriptions, see Table A–1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.
Chemical classification according to Irvine & Baragar (1971).

Ref. No.	Sample No.	Chemical Classification	Ref. No.	Sample No.	Chemical Classification
44	SL24–48	Calc-alkalic andesite	51	SL24–84	Calc-alkalic dacite
45	SL24–50	Calc-alkalic dacite	52	KW1	Tholeiitic basalt (diabase sill)
46	SL24–55	Calc-alkalic dacite	53	KW2	Tholeiitic basalt
47	SL24–68B	Calc-alkalic dacite	54	KW3	Tholeiitic basalt
48	SL24–71A	Calc-alkalic dacite	55	KW4	Tholeiitic basalt
49	SL24–95	Calc-alkalic andesite	56	KW5	Tholeiitic basalt
50	SL6–30P1	Calc-alkalic andesite	57	KW6	Tholeiitic basalt

Table A–2. Continued.

	Proterozoic Diabase Dike Rocks (Map Unit 8).						
Ref. No.	**58**	**59**	**60**	**61**	**62**	**63**	**64**
SiO_2	50.30	44.80	43.90	47.90	44.60	51.60	45.30
Al_2O_3	13.70	8.73	12.7	14.00	17.20	12.10	12.30
Fe_2O_3	3.26	2.39	2.40	2.84	4.05	2.30	3.40
FeO	9.65	9.64	10.80	6.08	7.78	12.90	5.63
MgO	5.14	20.4	5.87	10.90	7.40	3.50	12.50
CaO	9.70	7.60	13.7	11.20	9.50	7.10	11.20
Na_2O	2.37	1.35	2.83	1.67	2.05	2.45	1.73
K_2O	0.58	0.31	0.89	0.24	0.43	1.37	0.43
H_2O^+	1.44	0.57	2.48	2.03	2.76	0.84	3.64
H_2O^-	0.74	1.60	1.09	1.49	1.52	1.07	1.63
CO_2	0.88	0.60	1.17	0.23	1.30	0.32	0.61
TiO_2	1.58	0.70	1.80	0.69	0.59	3.22	0.68
P_2O_5	0.14	0.01	0.23	0.07	0.32	0.57	0.23
S	0.04	0.04	0.11	0.06	0.03	0.15	0.02
MnO	0.21	0.20	0.20	0.16	0.19	0.25	0.14
Total	99.7	98.9	100.2	99.6	99.7	99.7	99.4
S.G.	2.87	3.10	2.95	2.88	2.79	2.92	2.89

	Proterozoic Diabase Dike Rocks and Paleozoic Lamprophyre Dike Rocks (Map Units 8 and 9).					
Ref. No.	**65**	**66**	**67**	**68**	**69**	**70**
SiO_2	42.20	44.90	43.10	31.30	30.50	30.10
Al_2O_3	10.20	15.50	13.80	5.08	4.20	5.72
Fe_2O_3	3.81	5.48	4.63	12.00	11.43	8.33
FeO	5.84	6.68	9.15	4.45	5.35	5.91
MgO	9.10	3.92	5.24	19.40	18.80	13.9
CaO	14.4	11.70	10.40	13.4	13.20	20.2
Na_2O	1.78	3.50	3.10	0.13	0.40	0.35
K_2O	0.31	1.52	1.57	1.61	1.57	1.88
H_2O^+	3.01	1.98	2.98	5.03	4.55	3.80
H_2O^-	1.83	0.85	1.13	0.96	1.03	1.56
CO_2	6.26	0.78	0.95	2.72	3.30	3.02
TiO_2	0.54	1.57	1.55	3.61	4.01	3.30
P_2O_5	0.34	1.14	1.14	1.03	0.74	1.83
S	0.04	0.10	0.08	0.06	0.06	0.20
MnO	0.17	0.16	0.33	0.30	0.23	0.22
Total	99.8	99.8	99.2	101.1	99.4	100.3
S.G.	2.78	2.84	2.87	2.99	3.03	2.98

Notes: For sample descriptions, see Table A–1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.
Chemical classification according to Irvine & Baragar (1971).

Ref. No.	Sample No.	Chemical Classification	Ref. No.	Sample No.	Chemical Classification
58	SL22–9B	Diabase	65	SL14–206	Porphyritic diabase
59	SL28–11	Diabase	66	SL14–79A	Red alkalic diabase
60	SL14–224D	Diabase	67	SL20–25	Red alkalic diabase
61	SL29–22	Diabase	68	SL24–13	Lamprophyre
62	SL29–49	Diabase	69	SL24–21	Lamprophyre
63	Lighthouse	Diabase	70	SL24–54	Lamprophyre
64	SL14–90	Porphyritic diabase			

Table A–3. Trace element analyses (ppm) of whole-rock samples from Slate Islands.

	Archean Mafic to Intermediate Metavolcanic Rocks (Map Unit 1).					
Ref. No.	**1**	**2**	**3**	**4**	**5**	**6**
Ag(S)	<1	<1	<1	<1	<1	<1
Ba(A)	120	80	50	90	50	200
Be(S)	<1	<1	<1	<1	<1	<1
Co(A)	45	40	45	50	40	50
Cr(A)	420	360	260	440	360	440
Cu(A)	95	140	160	100	95	150
Ga(S)	15	15	15	15	15	15
Li(A)	8	15	6	15	6	20
Mo(S)	<1	<1	<1	<1	<1	<1
Ni(A)	110	100	90	110	100	160
Pb(A)	25	35	50	65	55	25
Sc(S)	40	50	50	25	40	50
Sn(S)	30	20	60	15	7	15
Sr(S)	10	100	80	70	90	70
V(S)	200	250	25	100	200	200
Y(S)	20	15	20	10	20	10
Zn(A)	100	100	100	85	80	200
Zr(S)	50	40	50	20	50	20

	Archean Mafic to Intermediate Metavolcanic and Intrusive Rocks (Map Units 1 and 4).					
Ref. No.	**7**	**8**	**9**	**10**	**11**	**12**
Ag(S)	<1	<1	<1	<1	<1	<1
Ba(A)	100	90	20	160	110	30
Be(S)	<1	<1	<1	<1	<1	<1
Co(A)	35	40	100	20	75	40
Cr(A)	170	200	1240	150	200	360
Cu(A)	110	140	55	50	160	30
Ga(S)	15	15	3	25	15	15
Li(A)	10	10	6	15	6	40
Mo(S)	1	1	1	<1	<1	<1
Ni(A)	60	60	1380	80	400	90
Pb(A)	10	15	20	40	15	25
Sc(S)	50	50	7	10	25	30
Sn(S)	7	25	9	4	15	<1
Sr(S)	20	300	60	200	20	100
V(S)	200	200	30	60	150	70
Y(S)	20	20	10	10	10	15
Zn(A)	75	110	50	70	140	110
Zr(S)	70	70	20	70	50	40

Notes: For sample descriptions, see Table A–1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Chemical Classification	Ref. No.	Sample No.	Chemical Classification
1	SL2–39C	Tholeiitic basalt	7	SL18–7	Calc-alkalic basalt
2	SL3–23	Tholeiitic basalt	8	SL18–22	Calc-alkalic basalt
3	SL10–15	Tholeiitic basalt	9	SL18–40	Ultramafic
4	SL10–45	Calc-alkalic basalt	10	SL12–159A	Calc-alkalic andesite
5	SL10–82	Tholeiitic basalt	11	SL20–30A	Calc-alkalic basalt
6	SL18–5B	Calc-alkalic basalt	12	SL20–37	Tholeiitic basalt

Table A–3. Continued.

	Archean Mafic to Intermediate Metavolcanic and Intrusive Rocks (Map Units 1 and 4).						
Ref. No.	**13**	**14**	**15**	**16**	**39**	**40**	**41**
Ag(S)	< 1	< 1	< 1	2	< 1	< 1	< 1
Ba(A)	20	210	180	190	40	30	40
Be(S)	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Co(A)	45	25	25	35	35	40	35
Cr(A)	560	220	400	210	160	720	920
Cu(A)	70	55	55	55	110	85	110
Ga(S)	15	15	15	15	15	15	10
Li(A)	20	20	4	15	7	15	6
Mo(S)	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Ni(A)	240	95	100	100	100	100	110
Pb(A)	8	10	10	10	25	10	10
Sc(S)	20	15	15	15	35	40	45
Sn(S)	10	< 1	2	4	20	2	7
Sr(S)	50	100	150	100	100	100	< 10
V(S)	50	60	90	100	150	200	100
Y(S)	< 10	< 10	< 10	< 10	< 10	15	< 10
Zn(A)	130	100	120	100	60	95	65
Zr(S)	40	150	70	40	20	30	30

	Archean Intermediate to Felsic Metavolcanic Rocks (Map Unit 2).							
Ref. No.	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Ag(S)	< 1	< 1	< 1	< 1	1	1	1	1
Ba(A)	440	430	140	300	430	110	300	200
Be(S)	< 1	< 1	< 1	< 1	1	1	1	1
Co(A)	20	6	15	15	20	10	5	5
Cr(A)	40	15	130	35	150	110	25	15
Cu(A)	25	7	100	110	55	60	6	30
Ga(S)	35	30	25	25	20	20	25	30
Li(A)	4	4	4	< 3	10	6	15	6
Mo(S)	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Ni(A)	35	15	75	40	75	40	10	7
Pb(A)	25	25	20	50	30	15	40	20
Sc(S)	5	10	10	10	25	10	5	5
Sn(S)	10	30	10	4	10	15	2	5
Sr(S)	300	300	200	60	100	300	300	200
V(S)	35	15	60	80	100	50	35	35
Y(S)	10	10	10	10	10	10	10	10
Zn(A)	35	70	90	35	45	35	15	30
Zr(S)	90	100	150	70	80	90	80	80

Notes: For sample descriptions, see Table A–1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Chemical Classification	Ref. No.	Sample No.	Chemical Classification
13	SL20–40B	Tholeiitic basalt	18	SL6–24G	Calc-alkalic dacite
14	SL20–53	Calc-alkalic andesite	19	SL12–111A	Calc-alkalic andesite
15	SL28–5B	Calc-alkalic andesite	20	SL12–199C	Calc-alkalic andesite
16	SL28–7B	Tholeiitic basalt	21	SL14–96C	Calc-alkalic basalt
39	SL14–126	Tholeiitic basalt	22	SL20–6C	Mugearite
40	SL20–90B	Tholeiitic basalt	23	SL24–17B	Calc-alkalic dacite
41	SL29–77B	Tholeiitic basalt	24	SL24–42K	Calc-alkalic dacite
17	SL4–12	Calc-alkalic dacite			

Table A-3. Continued.

	Archean Intermediate to Felsic Metavolcanic and Intrusive Rocks (Map Units 2 and 5).							
Ref. No.	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**
Ag(S)	< 1	< 1	< 1	3	< 1	< 1	< 1	< 1
Ba(A)	180	120	140	630	280	260	150	370
Be(S)	< 1	2	< 1	< 1	< 1	< 1	< 1	< 1
Co(A)	5	10	5	6	5	10	7	8
Cr(A)	15	40	55	10	55	110	15	15
Cu(A)	30	15	40	15	45	75	60	15
Ga(S)	30	20	20	20	20	30	40	40
Li(A)	6	4	8	6	6	3	4	9
Mo(S)	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Ni(A)	7	20	15	8	10	45	15	15
Pb(A)	15	10	10	15	10	10	15	15
Sc(S)	5	5	4	6	5	6	< 5	5
Sn(S)	60	< 1	10	25	< 1	15	8	2
Sr(S)	300	200	250	250	150	300	60	200
V(S)	35	20	35	35	40	50	30	35
Y(S)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Zn(A)	45	20	30	50	20	30	40	20
Zr(S)	80	25	60	70	50	50	45	30

	Archean Felsic to Intermediate Metavolcanic and Intrusive Rocks (Map Units 1, 2 and 5).							
Ref. No.	**33**	**34**	**35**	**36**	**37**	**38**	**42**	**43**
Ag(S)	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Ba(A)	300	200	360	200	240	400	230	140
Be(S)	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Co(A)	15	25	20	8	25	20	25	8
Cr(A)	420	100	190	40	540	440	35	40
Cu(A)	60	70	65	70	20	75	35	35
Ga(S)	20	20	25	15	10	15	25	25
Li(A)	6	8	6	5	10	8	20	6
Mo(S)	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Ni(A)	70	80	65	25	160	120	35	15
Pb(A)	15	20	20	< 10	20	15	15	20
Sc(S)	10	20	20	7	20	15	10	5
Sn(S)	30	6	15	< 1	< 1	15	4	2
Sr(S)	200	200	200	400	200	200	200	200
V(S)	80	100	7	45	70	90	50	40
Y(S)	< 10	< 10	< 10	25	< 10	< 10	20	< 10
Zn(A)	45	60	50	65	110	65	130	45
Zr(S)	60	70	60	100	100	50	300	70

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Chemical Classification	Ref. No.	Sample No.	Chemical Classification
25	SL24-42M	Calc-alkalic dacite	33	SL6-16A	Calc-alkalic andesite
26	SL28-9B	Calc-alkalic dacite	34	SL6-34	Calc-alkalic basalt
27	SL28-10C	Calc-alkalic dacite	35	SL6-58B	Calc-alkalic andesite
28	SL28-12	Calc-alkalic dacite	36	SL14-114X	Calc-alkalic dacite
29	SL28-23	Calc-alkalic dacite	37	SL14-146X	Calc-alkalic andesite
30	SL29-36	Calc-alkalic andesite	38	SL20-24B	Calc-alkalic andesite
31	SL30-31C	Calc-alkalic rhyolite	42	SL24-5B	Calc-alkalic andesite
32	SL31-49	Calc-alkalic dacite	43	SL24-12	Calc-alkalic dacite

Table A–3. Continued.

	Archean Felsic to Intermediate Intrusive Rocks (Map Unit 5).							
Ref. No.	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**
Ag(S)	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Ba(A)	670	640	460	450	550	580	700	660
Be(S)	< 1	< 1	< 1	< 1	< 1	< 1	1	1
Co(A)	9	10	10	10	9	10	10	10
Cr(A)	65	60	40	40	40	95	80	80
Cu(A)	7	85	7	5	3	15	75	40
Ga(S)	30	25	30	25	30	25	30	25
Li(A)	10	10	5	10	8	6	5	8
Mo(S)	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Ni(A)	25	30	20	20	20	35	35	30
Pb(A)	10	90	15	10	15	20	20	35
Sc(S)	70	5	5	< 5	5	5	7	7
Sn(S)	2	500	5	2	2	2	44	300
Sr(S)	500	800	500	400	500	450	600	600
V(S)	40	40	40	50	35	40	50	50
Y(S)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Zn(A)	55	75	60	70	55	60	45	60
Zr(S)	70	70	60	60	50	60	50	60

	Proterozoic Mafic Flow Rocks and Diabase Intrusive Rocks (Map Units 7 and 8).					
Ref. No.	**52**	**53**	**54**	**55**	**56**	**57**
Ag(S)	1	1	1	1	1	1
Ba(A)	170	180	130	140	100	140
Be(S)	1	1	1	1	1	1
Co(A)	50	60	60	55	60	50
Cr(A)	130	680	640	920	440	310
Cu(A)	220	50	60	55	120	150
Ga(S)	20	15	15	15	20	15
Li(A)	5	8	8	8	6	7
Mo(S)	1	1	1	1	1	1
Ni(A)	140	200	190	200	190	150
Pb(A)	25	25	35	25	15	20
Sc(S)	35	20	20	30	15	15
Sn(S)	7	4	6	4	4	3
Sr(S)	200	300	200	300	300	300
V(S)	200	200	200	250	150	200
Y(S)	20	15	10	15	10	15
Zn(A)	120	100	120	100	120	110
Zr(S)	80	90	70	100	70	90

Notes: For sample descriptions, see Table A–1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Chemical Classification	Ref. No.	Sample No.	Chemical Classification
44	SL24–48	Calc-alkalic andesite	51	SL24–84	Calc-alkalic dacite
45	SL24–50	Calc-alkalic dacite	52	KW1	Tholeiitic basalt (diabase sill)
46	SL24–55	Calc-alkalic dacite	53	KW2	Tholeiitic basalt
47	SL24–68B	Calc-alkalic dacite	54	KW3	Tholeiitic basalt
48	SL24–71A	Calc-alkalic dacite	55	KW4	Tholeiitic basalt
49	SL24–95	Calc-alkalic andesite	56	KW5	Tholeiitic basalt
50	SL6–30P1	Calc-alkalic andesite	57	KW6	Tholeiitic basalt

Table A-3. Continued.

	Proterozoic Diabase Dike Rocks (Map Unit 8).						
Ref. No.	**58**	**59**	**60**	**61**	**62**	**63**	**64**
Ag(S)	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Ba(A)	220	120	190	140	430	450	280
Be(S)	< 1	< 1	< 1	< 1	< 1	3	< 1
Co(A)	45	95	50	60	65	35	55
Cr(A)	160	2160	120	1000	50	10	1340
Cu(A)	160	100	55	160	170	130	50
Ga(S)	15	8	10	15	9	20	8
Li(A)	15	6	20	8	9	9	9
Mo(S)	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Ni(A)	65	860	55	320	100	15	400
Pb(A)	50	< 10	< 10	< 10	10	25	15
Sc(S)	40	25	35	15	40	30	40
Sn(S)	5	< 1	< 1	3	45	8	< 1
Sr(S)	200	100	300	400	600	200	70
V(S)	200	200	300	150	150	150	200
Y(S)	20	15	30	< 10	10	50	20
Zn(A)	170	100	130	70	100	170	75
Zr(S)	150	100	200	45	45	400	100

	Proterozoic Diabase Dike Rocks and Paleozoic Lamprophyre Dike Rocks (Map Units 8 and 9).					
Ref. No.	**65**	**66**	**67**	**68**	**69**	**70**
Ag(S)	< 1	< 1	< 1	< 1	< 1	< 1
Ba(A)	120	2100	2200	90	620	120
Be(S)	< 1	3	2	4	3	4
Co(A)	55	45	45	70	80	60
Cr(A)	1560	7	7	620	860	440
Cu(A)	65	180	170	140	170	480
Ga(S)	8	20	15	8	15	10
Li(A)	6	10	15	10	15	10
Mo(S)	< 1	< 1	< 1	< 1	< 1	< 1
Ni(A)	360	25	25	520	580	400
Pb(A)	< 10	50	35	15	15	< 10
Sc(S)	30	7	6	15	10	10
Sn(S)	< 1	10	< 1	< 1	3	< 1
Sr(S)	900	1000	1000	400	400	500
V(S)	100	200	100	90	70	80
Y(S)	15	15	15	20	< 10	20
Zn(A)	180	150	150	160	120	120
Zr(S)	100	150	80	300	200	250
Nb(S)	-	-	-	< 100	-	< 100
Ce(S)	-	-	-	< 100	-	< 100
La(S)	-	-	-	< 30	-	< 30

Ref. No.	Sample No.	Chemical Classification
58	SL22-9B	Diabase
59	SL28-11	Diabase
60	SL14-224D	Diabase
61	SL29-22	Diabase
62	SL29-49	Diabase
63	Lighthouse	Diabase
64	SL14-90	Porphyritic diabase

Ref. No.	Sample No.	Chemical Classification
65	SL14-206	Porphyritic diabase
66	SL14-79A	Red alkalic diabase
67	SL20-25	Red alkalic diabase
68	SL24-13	Lamprophyre
69	SL24-21	Lamprophyre
70	SL24-54	Lamprophyre

Table A-3. Continued.

Sample 69 – Additional analyses			
Ce(ICP-MS)	170	Tm(ICP-MS)	0.2
La(ICP-MS)	73	Yb(ICP-MS)	1.1
Nd(ICP-MS)	93	Lu(ICP-MS)	0.15
Y(ICP-MS)	18	Nb(X)	115
Pr(ICP-MS)	24	Rb(X)	50
Sm(ICP-MS)	17	Sr(X)	735
Eu(ICP-MS)	4.9	Y(X)	23
Gd(ICP-MS)	11	Zr(X)	275
Tb(ICP-MS)	1.5	Th(X)	14
Dy(ICP-MS)	6.3	Ta(X)	< 10
Ho(ICP-MS)	0.98	Ga(X)	16
Er(ICP-MS)	1.8	Cs(X)	< 3

ICP-MS - Inductively coupled plasma - mass spectroscopy
X - X-Ray Fluorescence

Table A–4. Normative minerals (CIPW norm) for whole-rock samples from Slate Islands.

	Archean Mafic to Intermediate Metavolcanic Rocks (Map Unit 1).					
Ref. No.	**1**	**2**	**3**	**4**	**5**	**6**
Ap	0.24	0.17	0.24	0.08	0.29	0.08
Po	0.06	0.09	0.09	1.87	0.09	0.15
Il	2.30	2.24	2.72	1.55	2.19	1.68
Or	1.37	1.49	0.74	2.54	1.04	7.83
Ab	8.18	18.58	18.28	20.89	26.33	20.21
An	40.59	33.63	29.04	34.26	27.13	38.00
C	1.72	2.87	0.72	1.87	0.66	0.29
Mt	14.12	16.92	10.37	18.99	10.08	12.99
Hm	12.49	13.59	9.53	6.35	8.91	9.60
En	6.95	2.27	6.88	5.11	2.10	6.20
Fs	6.76	4.80	11.88	5.04	11.98	1.80
Q	–	–	–	–	–	–
Di	–	–	–	–	–	–
Fo	–	–	–	–	–	–
Fa	–	–	–	–	–	–
Ne						
Lc	5.22	3.36	9.51	1.47	9.23	1.16
He	–	–	–	–	–	–
Ln						
DI	16.50	22.33	25.89	28.53	29.46	34.24
CI	42.61	43.78	44.74	35.26	43.04	27.53
NPC	82.38	63.05	59.97	60.73	49.27	63.93

Ap – Apatite; Po – Pyrrhotite; Il – Ilmenite; Or – Orthoclase; Ab – Albite; An – Anorthite; C – Corundum; Mt – Magnetite; Hm – Hematite; En – Enstatite; Fs – Ferrosilite; Q – Quartz; Di – Diopside; Fo – Forsterite; Fa – Fayalite; Ne – Nepheline; Lc – Leucite; He – Hedenbergite; Ln – Larnite; DI – Differentiation Index; CI – Colour Index; NPC – Normative plagioclase composition (Anorthite).
Note: For sample descriptions, see Table A–1.

Ref. No.	Sample No.	Chemical Classification	Ref. No.	Sample No.	Chemical Classification
1	SL2–39C	Tholeiitic basalt	4	SL10–45	Calc-alkalic basalt
2	SL3–23	Tholeiitic basalt	5	SL10–82	Tholeiitic basalt
3	SL10–15	Tholeiitic basalt	6	SL18–5B	Calc-alkalic basalt

	Archean Mafic to Intermediate Metavolcanic and Intrusive Rocks (Map Units 1 and 4).					
Ref. No.	**7**	**8**	**9**	**10**	**11**	**12**
Ap	0.32	0.32	0.03	0.48	0.20	0.10
Po	0.06	0.09	0.23	0.03	0.50	0.03
Il	2.39	2.59	0.59	1.22	2.34	2.39
Or	1.94	1.18	–	4.96	12.35	0.67
Ab	30.16	32.81	–	39.26	18.76	15.12
An	25.75	23.87	11.15	18.30	25.19	30.90
C	1.60	0.69	3.06	–	2.71	–
Mt	11.86	4.95	–	3.30	1.84	1.71
Hm	7.99	4.93	–			
En	6.69	–	–	8.69	7.70	15.57
Fs	7.08	13.05	35.59	3.80	8.38	11.34
Q	–	2.01	34.07	18.38	20.04	4.26
Di	–	2.21	7.47	1.14	–	10.96
Fo	–	–	1.04			
Fa	–	–	0.11			
Ne						
Lc	4.16	11.32	6.17			
He	–	–	0.49	0.44	–	6.96
Ln						
DI	38.80	33.99	1.16	62.59	51.14	20.04
CI	35.08	41.74	86.95	18.59	20.26	48.93
NPC	44.59	40.68	84.49	30.53	55.86	65.83

Note: For sample descriptions, see Table A–1.

Ref. No.	Sample No.	Chemical Classification	Ref. No.	Sample No.	Chemical Classification
7	SL18–7	Calc-alkalic basalt	10	SL12–159A	Calc-alkalic andesite
8	SL18–22	Calc-alkalic basalt	11	SL20–30A	Calc-alkalic basalt
9	SL18–40	Ultramafic	12	SL20–37	Tholeiitic basalt

Table A–4. Continued.

	Archean Mafic to Intermediate Metavolcanic and Intrusive Rocks (Map Units 1 and 4).						
Ref. No.	**13**	**14**	**15**	**16**	**39**	**40**	**41**
Ap	0.15	0.27	0.52	0.23	0.05	0.15	0.14
Po	0.03	0.06	0.06	0.06	0.23	0.32	0.17
Il	1.89	1.60	2.29	2.20	1.06	2.11	1.16
Or	0.65	5.48	4.43	5.78	0.74	1.07	0.74
Ab	16.17	33.98	34.91	12.54	16.02	21.19	15.97
An	29.67	15.67	20.98	31.51	36.88	33.30	32.49
C	–	3.27	–	–			
Mt	2.61	1.61	1.66	1.81	2.64	3.92	4.26
Hm							
En	22.74	15.57	2.39	10.50	9.09	20.83	15.20
Fs	13.10	7.96	1.52	12.75	4.73	9.12	5.31
Q	5.84	14.53	15.96	9.66	–	2.22	2.65
Di	4.76	–	9.84	6.30	19.44	4.18	16.80
Fo					0.19	–	–
Fa					0.11	–	–
Ne							
Lc							
He	2.39	–	5.45	6.66	8.83	1.59	5.12
Ln							
DI	22.66	53.99	55.29	27.98			
CI	47.49	26.74	23.15	40.21			
NPC	63.37	30.30	36.16	70.32			

Note: For sample descriptions, see Table A–1.

Ref. No.	Sample No.	Chemical Classification	Ref. No.	Sample No.	Chemical Classification
13	SL20–40B	Tholeiitic basalt	39	SL14–126	Tholeiitic basalt
14	SL20–53	Calc-alkalic andesite	40	SL20–90B	Tholeiitic basalt
15	SL28–5B	Calc-alkalic andesite	41	SL29–77B	Tholeiitic basalt
16	SL28–7B	Tholeiitic basalt			

	Archean Intermediate to Felsic Metavolcanic Rocks (Map Unit 2).							
Ref. No.	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Ap	0.29	0.31	0.46	0.53	0.42	0.43	0.22	0.91
Po	0.34	0.06	0.06	0.06	0.09	0.12	0.03	0.03
Il	0.83	1.22	1.24	1.41	1.69	1.49	0.88	0.82
Or	10.83	10.08	7.89	17.20	11.37	5.95	7.46	6.04
Ab	29.92	40.80	35.45	26.24	24.63	57.71	27.99	53.10
An	18.02	14.59	18.17	20.43	33.09	17.95	23.35	13.25
C	1.10	0.57	–	2.25	–	–	0.92	–
Mt	0.68	2.22	3.34	2.23	1.32	0.21	0.53	0.16
Hm	0.09	–	–	–	–	–	–	–
En	0.62	1.92	7.61	2.95	4.46	–	0.86	0.93
Fs	–	1.14	3.29	1.43	6.00	–	0.32	0.38
Q	37.28	27.09	21.44	25.28	13.68	–	37.44	24.59
Di	–	–	0.77	–	1.49	6.27	–	–
Fo	–	–	–	–	–	2.94	–	–
Fa	–	–	–	–	–	2.57	–	–
Ne								
Lc	–	–	–	–	–	0.03	–	–
He	–	–	0.29	–	1.75	4.34	–	–
Ln								
DI	78.03	77.98	64.78	68.72	49.69	63.68	72.89	83.72
CI	2.23	6.49	16.53	8.02	16.71	17.81	2.59	2.55
NPC	36.21	25.20	32.57	42.12	55.87	22.66	44.04	19.04

Note: For sample descriptions, see Table A–1.

Ref. No.	Sample No.	Chemical Classification	Ref. No.	Sample No.	Chemical Classification
17	SL4–12	Calc-alkalic dacite	21	SL14–96C	Calc-alkalic basalt
18	SL6–24G	Calc-alkalic dacite	22	SL20–6C	Mugearite
19	SL12–111A	Calc-alkalic andesite	23	SL24–17B	Calc-alkalic dacite
20	SL12–199C	Calc-alkalic andesite	24	SL24–42K	Calc-alkalic dacite

Table A–4. Continued.

	Archean Intermediate to Felsic Metavolcanic and Intrusive Rocks (Map Units 2 and 5).							
Ref. No.	25	26	27	28	29	30	31	32
Ap	0.21	0.17	0.17	0.22	0.12	0.25	0.19	0.16
Po	0.03	0.06	0.12	0.06	0.06	0.15	0.06	0.25
Il	0.92	0.65	0.70	0.92	0.73	0.59	0.56	0.62
Or	5.63	2.09	5.81	16.84	8.29	7.35	3.80	9.74
Ab	45.25	46.03	33.86	33.31	29.35	35.16	58.62	32.87
An	15.75	10.30	20.76	7.15	11.87	22.34	9.59	10.65
C	–	–	–	3.55	2.76	–	0.01	5.52
Mt	0.47	0.08	0.35	0.81	0.38	2.70	0.15	0.55
Hm	–	–	–	–	–	–	–	–
En	0.89	–	1.43	2.87	1.19	6.45	1.27	1.55
Fs	0.24	–	0.92	3.04	0.75	1.76	0.28	0.18
Q	30.01	33.36	35.37	31.25	44.51	24.67	25.48	37.89
Di	0.48	1.68	0.33	–	–	0.48	–	–
Fo	–	–	–	–	–	–	–	–
Fa	–	–	–	–	–	–	–	–
Ne								
Lc	–	–	–	–	–	–	–	–
He	.11	1.17	0.19	–	–	0.11	–	–
Ln								
DI	80.90	81.48	75.04	81.40	82.15	67.17	87.90	80.52
CI	3.12	3.58	3.92	7.63	3.04	12.09	2.26	2.90
NPC	24.70	17.42	36.53	16.82	27.60	35.29	13.36	23.38

Note: For sample descriptions, see Table A–1.

Ref. No.	Sample No.	Chemical Classification	Ref. No.	Sample No.	Chemical Classification
25	SL24–42M	Calc-alkalic dacite	29	SL28–23	Calc-alkalic dacite
26	SL28–9B	Calc-alkalic dacite	30	SL29–36	Calc-alkalic andesite
27	SL28–10C	Calc-alkalic dacite	31	SL30–31C	Calc-alkalic rhyolite
28	SL28–12	Calc-alkalic dacite	32	SL31–49	Calc-alkalic dacite

	Archean Felsic To Intermediate Metavolcanic and Intrusive Rocks (Map Units 1, 2 and 5).							
Ref. No.	33	34	35	36	37	38	42	43
Ap	0.22	0.37	0.30	0.27	0.23	0.35	1.18	0.25
Po	0.09	0.06	0.12	0.09	0.03	0.38	0.09	0.09
Il	1.07	1.68	1.30	0.73	1.29	1.33	3.69	1.89
Or	7.70	5.43	9.90	8.03	12.20	13.06	10.67	9.93
Ab	30.16	25.53	29.21	51.42	34.06	29.97	22.40	33.68
An	24.30	32.97	21.58	12.88	18.40	19.19	23.27	20.68
C	0.22	–	4.42	–	4.26	–	1.20	–
Mt	0.18	2.85	0.57	1.21	2.37	1.39	1.85	0.10
Hm							–	0.53
En	4.40	3.62	5.18	14.88	9.97	2.13	5.28	0.47
Fs	4.80	2.62	5.99	1.96	5.44	0.57	3.05	–
Q	26.87	14.51	21.45	15.03	11.75	11.63	27.33	30.65
Di	–	6.36	–	2.60	–	18.28	–	1.76
Fo								
Fa								
Ne								
Lc								
He	–	4.02	–	0.91	–	4.16	–	–
Ln								
DI	64.72	45.47	60.56	74.49	58.01	52.66	60.40	74.26
CI	10.45	21.14	13.03	12.28	19.07	27.42	13.87	4.74
NPC	43.17	54.90	41.05	19.10	33.74	39.27	49.47	36.66

Note: For sample descriptions, see Table A–1.

Ref. No.	Sample No.	Chemical Classification	Ref. No.	Sample No.	Chemical Classification
33	SL6–16A	Calc-alkalic andesite	37	SL14–146X	Calc-alkalic andesite
34	SL6–34	Calc-alkalic basalt	38	SL20–24B	Calc-alkalic andesite
35	SL6–58B	Calc-alkalic andesite	42	SL24–5B	Calc-alkalic andesite
36	SL14–114X	Calc-alkalic dacite	43	SL24–12	Calc-alkalic dacite

Table A–4. Continued.

	Archean Felsic to Intermediate Intrusive Rocks (Map Unit 5).							
Ref. No.	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**
Ap	0.27	0.32	0.29	0.22	0.34	0.35	0.33	0.29
Po	0.03	0.03	0.03	0.03	0.03	0.06	0.12	0.06
Il	0.97	0.78	0.73	0.80	0.70	0.78	0.96	0.77
Or	14.75	9.42	11.99	10.64	6.89	12.41	13.08	3.58
Ab	31.57	39.20	37.73	36.93	46.14	34.88	30.94	59.13
An	23.51	18.26	13.88	16.70	17.56	19.64	20.67	10.17
C	0.03	–	1.08	2.84	0.22	–		
Mt	2.04	1.13	2.32	2.18	1.81	1.12	2.14	1.89
Hm	–	–	0.34	–	–	–		
En	4.04	4.49	3.34	4.40	3.84	4.79	4.19	1.37
Fs	1.38	2.18	–	1.11	1.25	2.75	0.99	0.21
Q	21.43	21.15	28.26	24.15	21.23	22.23	20.83	13.15
Di	–	2.15	–	–	–	0.66	4.78	8.28
Fo								
Fa								
Ne								
Lc								
Hc	–	0.91	–	–	–	0.33	0.98	1.10
Ln								
DI	67.74	69.77	77.99	71.72	74.26	69.53	64.84	75.33
CI	8.42	11.63	6.74	8.49	7.59	10.43	14.04	13.62
NPC	41.24	30.51	25.75	29.89	26.40	34.67	38.64	13.95

Note: For sample descriptions, see Table A–1.

Ref. No.	Sample No.	Chemical Classification	Ref. No.	Sample No.	Chemical Classification
44	SL24–48	Calc-alkalic andesite	48	SL24–71A	Calc-alkalic dacite
45	SL24–50	Calc-alkalic dacite	49	SL24–95	Calc-alkalic andesite
46	SL24–55	Calc-alkalic dacite	50	SL6–30P1	Calc-alkalic andesite
47	SL24–68B	Calc-alkalic dacite	51	SL24–84	Calc-alkalic dacite

	Proterozoic Mafic Flow Rocks and Diabase Intrusive Rocks (Map Units 7 and 8).					
Ref. No.	**52**	**53**	**54**	**55**	**56**	**57**
Ap	0.34	0.46	0.46	0.41	0.55	0.59
Po	0.06	0.06	0.03	0.06	0.06	0.06
Il	3.02	4.71	4.89	4.38	4.76	5.20
Or	2.85	3.11	1.87	2.66	0.76	1.88
Ab	19.15	16.52	16.71	14.77	13.41	17.24
An	33.59	21.70	20.58	19.02	25.23	32.07
C						
Mt	4.59	5.98	6.11	5.73	5.96	6.36
Hm						
En	9.67	9.21	10.80	12.48	15.06	8.53
Fs	8.17	6.15	5.49	6.43	6.29	4.18
Q	2.09	5.57	3.40	5.38	7.81	5.87
Di	9.49	16.78	20.55	19.78	14.75	12.62
Fo						
Fa						
Ne						
Lc						
He	6.99	9.76	9.11	8.89	5.37	5.40
Ln						
DI	24.09	25.20	21.98	22.81	21.98	24.99
CI	41.93	52.58	56.96	57.70	52.19	42.29
NPC	62.31	55.33	53.71	54.84	63.95	63.68

Note: For sample descriptions, see Table A–1.

Ref. No.	Sample No.	Chemical Classification	Ref. No.	Sample No.	Chemical Classification
52	KW1	Tholeiitic basalt (diabase sill)	55	KW4	Tholeiitic basalt
53	KW2	Tholeiitic basalt	56	KW5	Tholeiitic basalt
54	KW3	Tholeiitic basalt	57	KW6	Tholeiitic basalt

Table A–4. Continued.

	Proterozoic Diabase Dike Rocks (Map Unit 8).						
Ref. No.	**58**	**59**	**60**	**61**	**62**	**63**	**64**
Ap	0.34	0.02	0.56	0.17	0.79	1.36	0.57
Po	0.11	0.11	0.32	0.17	0.08	0.42	0.06
Il	3.11	1.38	3.58	1.37	1.19	6.28	1.38
Or	3.55	1.91	5.52	1.48	2.71	8.32	2.72
Ab	20.75	11.88	8.33	14.75	18.47	21.27	15.67
An	25.90	17.52	20.56	31.32	38.82	18.44	26.25
C							
Mt	4.62	3.32	3.65	4.30	3.23	3.42	3.38
Hm							
En	8.59	8.70	–	18.05	7.81	6.88	5.58
Fs	8.78	2.61	–	5.14	6.38	12.88	1.72
Q	5.25	–	–	–	–	9.00	–
Di	10.05	13.71	21.73	16.77	4.38	4.46	19.93
Fo	–	26.49	3.68	1.77	6.85	–	12.97
Fa	–	8.76	4.10	0.55	6.17	–	4.41
Ne	–	–	9.09	–	–	–	–
Lc	–	–	–	–	–	–	–
He	8.96	3.59	19.18	4.16	3.12	7.27	5.36
Ln	–	–	–	–	–	–	–
DI	29.55	13.79	22.94	16.23	21.17	38.59	18.39
CI	44.10	68.55	55.93	52.11	39.13	41.19	54.73
NPC	54.06	58.16	43.20	66.68	66.46	44.97	61.23

Note: For sample descriptions, see Table A–1.

Ref. No.	Sample No.	Chemical Classification	Ref. No.	Sample No.	Chemical Classification
58	SL22–9B	Diabase	62	SL29–49	Diabase
59	SL28–11	Diabase	63	Lighthouse	Diabase
60	SL14–224D	Diabase	64	SL14–90	Porphyritic diabase
61	SL29–22	Diabase			

	Proterozoic Diabase Dike Rocks and Paleozoic Lamprophyre Dike Rocks (Map Units 8 and 9).					
Ref. No.	**65**	**66**	**67**	**68**	**69**	**70**
Ap	0.89	2.75	2.81	2.61	1.91	4.64
Po	0.12	0.29	0.23	0.18	0.18	0.60
Il	1.16	3.10	3.13	7.48	8.47	6.85
Or	2.07	9.35	9.87	–	–	–
Ab	9.26	21.45	19.42	–	–	–
An	21.39	22.98	20.31	9.29	5.59	9.27
C						
Mt	3.34	8.27	7.14	8.08	8.89	7.61
Hm						
En	–	–	–	–	–	–
Fs	–	–	–	–	–	–
Q	–	–	–	–	–	–
Di	32.14	16.57	12.76	3.63	5.52	1.45
Fo	7.50	1.73	5.58	35.76	34.72	26.04
Fa	4.10	0.99	5.04	7.90	7.04	5.69
Ne	4.20	5.07	4.58	0.65	2.04	1.75
Lc	–	–	–	8.15	8.10	9.53
He	13.87	7.45	9.12	0.63	0.89	0.25
Ln	–	–	–	15.64	16.66	26.32
DI	15.53	35.87	33.88	8.80	10.14	11.28
CI	62.08	38.11	42.77	63.49	65.52	47.89
NPC	54.23	41.29	40.70	87.95	58.32	72.96

Note: For sample descriptions, see Table A–1.

Ref. No.	Sample No.	Chemical Classification	Ref. No.	Sample No.	Chemical Classification
65	SL14–206	Porphyritic diabase	68	SL24–13	Lamprophyre
66	SL14–79A	Red alkalic diabase	69	SL24–21	Lamprophyre
67	SL20–25	Red alkalic diabase	70	SL24–54	Lamprophyre

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CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
		LENGTH			
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
		AREA			
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
		VOLUME			
1 cm^3	0.061 02	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.308 0	cubic yards	1 cubic yard	0.764 555	m^3
		CAPACITY			
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
		MASS			
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 908 8**	t
		CONCENTRATION			
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

	Multiplied by	
1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note: Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in co-operation with the Coal Association of Canada.

MAPS
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